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THE

USE OF THE GLOBES

DISPLAYED IN A VARIETY OF SIMPLE AND INSTRUCTIVE PROBLEMS;

EXHIBITING

THE MOTIONS OF THE EARTH AND OF THE HEAVENLY BODIES, AND LEADING TO A KNOWLEDGE OF THE

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LONDON: SIMPKIN, MARSHALL, AND CO.

EDINBURGH: J. MENZIES, LIVERPOOL: G. PHILIP.

1844.

Printed by Thomas I. White, 65, Fleet-street, Dublin.

PREFACE.

The study of the Globes has been recommended as an important branch of education by many eminent men. It lies, as it were, at the foundation of the science of Geography and Astronomy; and its importance in the theory and practice of Navigation is unquestionable. But, though it is thus recommended, and possesses in itself so strong claims on our attention, it has not yet received in our colleges and public schools that degree of notice which it merits. This seems to arise in some degree from necessity. Studies of another kind, and captivating in themselves, press with unceasing importunity —the demands of the University are imperative— its honours encouraging, and it cannot be fairly expected that those who are candidates for its laurels should much swerve from a path which so frequently leads to independence and fame. Thus the time which can be spared for the consideration of subjects not within the college course is necessarily limited, except in the case of such pupils as are not preparing for the University.

Yet, this branch of science has not been entirely overlooked. It has found a favourable reception in some of the best schools, and, instead of operating as a draw-back upon other, and severer studies, it exercises an opposite effect, by the relaxation and pleasing variety which it affords.

If the above observations be correct, it would seem that a treatise on globes, to find countenance in our public schools, should be concise, and interesting as far as practical utility will admit. The following little book has been arranged with a regard to both these points.

The terrestrial globe is viewed in two aspects; first, as a complete map of the earth; and secondly, as an instrument by which the motions of the earth, and other interesting phenomena, may be illustrated.

In accordance with the former of these views, the learner is first made familiar with the great natural divisions of the earth, by a variety of introductory exercises. These are chiefly intended for the younger students. By means of this use of the Terrestrial Globe, (in general unnoticed by writers on the subject,) a knowledge of the outline of Geography may be acquired, with more speed and accuracy than by any other means. To extend this part of the subject, without much increasing the size of the book, a table of the principal islands, with the longitude and latitude in which they may severally be found, is inserted. All the requisite definitions are given. The circles of the sphere, with their divisions and uses, are explained; after which follows a collection of the most useful problems, and, through these are introduced, such remarks and questions as are suited to make them clearly understood.

The exercises on the celestial globe are presented to the learner in a similar manner.

For the benefit of those who study the Globes as a part of the theory of Navigation, a plate of the mariner's compass, with a copious compass table, is introduced.

Books consulted—Keith, Adams, Field, and Sharman, on Globes. Moore's Navigation, Ferguson's Astronomy, and Murray's Encyclopedia of Geography.

PART I.

SECTION I.

INTRODUCTORY EXERCISES ON THE GLOBE.

1. What does the terrestrial globe represent? The Earth.

2. In what respect does it represent the earth? 1st, In its form; 2d, in the motions of which it is susceptible; and 3d, in having the various portions of land and water described on its surface, according to their positions on the earth.

3. Is the earth exactly like the artificial globe in form? Not exactly, but very nearly so; the only difference is, that the earth is somewhat flat at the poles.

4. What do you mean by the poles of the globe? The extremities of the line or spindle on which it turns.

5. Is the earth similarly supported? No; but because the earth turns round, we imagine a line on which it turns, the extremities of which line, or axis, we call the poles of the earth.

6. How is it known that the earth is globular? There are many proofs of it; some of the most obvious are as follow:—1st, When to a spectator a ship first makes its appearance, the upper part of the rigging alone is perceptible; as it approaches,

the other parts become visible; and the last part that is seen is the hull. The contrary takes place as a ship recedes. 2nd, Navigators by sailing in a direct course, either eastward or westward, have returned to the port from which they had set out. 3rd, In an eclipse, when the earth's shadow is cast upon the moon, it is always of a circular form; but, no body, except a sphere, will in all positions project a circular shadow.

THE SURFACE OF THE GLOBE—GEOGRAPHICAL DIVISIONS.

1. How is the surface of the terrestrial globe portioned out? There are five grand divisions of water marked on its surface, and also five great portions of land.

Oceans.

2. Which are the five divisions of water? The Pacific Ocean, the Atlantic Ocean, the Indian Ocean, and the Northern and Southern Oceans.

Point these out on the globe.

Continents.

3. Which are the five great divisions of land? Europe, Asia, Africa, America, and New Holland, or Australia.

Point out these Continents.

Seas.

4. There are also several Seas marked on the globe. Which are those that lie in or about Europe?

The North Sea,
The White Sea,
The Baltic Sea,

The Black Sea,
The Sea of Azoph,
The Gulfs of Finland and Bothnia,
The Categat,
The Sea of Marmara,
The Grecian Sea,
The Mediterranean Sea.

Point out these Seas on the globe.

5. Which are the principal Seas in or about Asia?

The Sea of Okhotsk,
The Sea of Kamtskatka,
The Arabian Sea,
The Caspian Sea,
The Red Sea, or Arabian Gulf,
The Chinese Sea,
The Dead Sea,
The Sea of Aral,
The Sea of Japan.

Point out those Seas on the globe.

6. What large portions of water lie in or about America? In North America there are—

The Gulf of California,
The Gulf of Panama,
The Caribbean Sea,
The Bay of Honduras,
The Gulf of Mexico,
The Gulf of Florida,
The Bay of Fundy,
The Gulf of St. Lawrence,
Baffin's Bay,
Hudson's Bay,
And the five great Lakes in Canada.

Point out all these on the globe.

7. Which are the principal portions of water

in or about South America? With the exception of the Gulfs of Maracaibo and Darien, and the great Rivers Amazon and Laplata, there are no remarkable pieces of water in South America. Africa also, so far as it is known, seems destitute of inland seas.

Point out the above-named Gulfs and Rivers.

ISLANDS.

(See the Table of the Longitudes and Latitudes, p. 7.)

1. Are there not marked on the globe many other important portions of land, besides the Continents? Yes; the Oceans and Seas are diversified by innumerable Islands. These vary in size, shape, and distance from each other; some of them appear in groups or clusters.

Islands in the Atlantic.

2. Name the principal islands in the Atlantic? Iceland, Newfoundland, the Shetland Is., the Ferroe Is., the Azores, the Madeiras, the Cape Verd Is., the Bissagos, Ascension, St. Helena, Trinidad, the Falkland Is., the South Shetland Is., Bermudas, and the West India Islands.

Point out those islands on the globe.

Islands in the Indian Ocean.

3. Which are the principal Islands in the Indian Ocean? The Island of Socotra, the Lacadive Is., the Maldive Is., the Seychelle Is., Madagascar, the Comora Is., the Andaman Is., the Nicobar Is., the Chagos Is., Prince Edward's Is., the Island of Desolation, &c.

Point out those on the globe.

Islands in the Pacific Ocean.

4. The Islands of the Pacific Ocean are very

numerous; the following may be readily found. Point them out on the globe.

The Northern Archipelago, the Japan Is., the Loo-choo Is., the Philippine Is., the Island of Formosa, the East India Is., New Guinea, New Ireland, the isles of Solomon, the New Hebrides, the Friendly Is., New Zealand, New Caledonia, Van Diemen's Land; the Aukland Is., the Society Is., the Low Is., the Sandwich Is., the Gallipago Is., Juan Fernandes, &c.

Islands in the Mediterranean.

5. Are there not some Islands in the Mediterranean? Yes, many; the principal are the Baleâric Is., Sardinia, Corsica, Sicily, Candia, Cyprus, Rhodes.

Point out those islands on the globe.

Islands in the Polar Seas.

6. Which are the principal Islands in the Polar Seas? In the Antartic Sea there have been many islands of ice discovered, from time to time, some of which are marked on the globe; but Captains Ross and Crozier have, within the last year, discovered very extensive tracts of land there, some portions of which are insulated, and contain volcanoes in a state of action. These lands and islands are situated between the 70th and 79th degrees of latitude, and between 165 and 175 degrees of east longitude.

In the Arctic Sea there are many considerable islands, as Nova Zembla, Spitzbergen, the Georgian Is., Atrikansoi, New Siberia, the Loffoden Is., and others. Also Greenland, which, from its extent, may be considered a Continent, rather than

an Island. It was long supposed to be a part of America; but recent discoveries have proved it to be unconnected with any land.

10. Point out those Islands in the Arctic Ocean.

The Large Rivers.

1. Are there Rivers marked on the globe? Yes; there are some of the large rivers very conspicuous.

Point out some of them.

In Europe—there are the Danube, the Don, the Dnieper, the Volga, the Dniester, the Rhine, the Elbe, and Vistula.

In Asia—the Euphrates, Tigris, Obi, Ganges, Lena, Amour, Yang-tse-kiang, Cambodia, Indus, and Hoang-ho.

In Africa—the Nile, Niger, Senegal, Zaire, and Gambia.

In North America—the Columbia, St. Lawrence, Ohio, Mackenzie, Mississippi, Illinois, and Missouri.

In South America—the Amazon, Orinoco, La Plata, Araguay, and St. Francis.

It is obvious that exercises like the above may be greatly extended. This may be done, in a good measure, by means of the annexed Table of Islands.

Table of the principal Islands and groups of Islands marked on the globe, with the latitude and longitude of the centre of each group or island.

		Long.		Lat.	
Achill Island	Atlantic Ocean	10	31 W	54	7 N
Admiralty Island	Pacific Ocean	147	0 E	2	10 S
Aland	Baltic Sea	20	5 E	60	45 N
Albemarle Isl.	Pacific Ocean	91	30 W	1	30 S
Alderney	English Channel	2	12 W	49	45 N
Alsan	Baltic Sea	11	0 E	54	10 N
Amsterdam	Indian Ocean	123	4 E	0	10 N
Andaman	Bay of Bengal	93	11 E	13	30 N
Andros	Grecian Sea	252	0 E	38	0 N
Anglesea	Irish Sea	3	30 W	53	20 N
Anguilla	Caribbean Sea	62	35 W	18	15 N
Anna Bonn	Atlantic Ocean	5	30 E	2	5 S
Anticosti	Gulf St. Lawrence	63	0 W	49	30 N
Antigua	Caribbean Sea	61	0 W	17	30 N
Antiparos	Grecian Sea	25	44 E	37	8 N
Apularia	Indian Ocean	87	30 E	9	0 S
Archip. of Mergui	Bay of Bengal	98	0 E	12	0 N
Arran	Atlantic Ocean	5	20 W	55	40 N
Ascension	Atlantic Ocean	14	0 W	7	45 S
Auckland Isles	Southern Ocean	168	0 E	50	0 S
Azores	Atlantic Ocean	27	0 W	39	0 N
Bahama Isles	Caribbean Sea	78	0 W	25	0 N
Banca	Indian Ocean	106	0 E	2	0 S
Barbadoes	Caribbean Sea	59	43 W	13	5 N
Barbuda	Caribbean Sea	61	50 W	17	50 N
Bartholemew	Carribean Sea	63	40 W	17	46 N
Belle Isle	Bay of Biscay	3	0 W	47	0 N
Belle Isle	Atlantic Ocean	56	25 W	51	48 N
Bermuda	Atlantic Ocean	64	33 W	32	22 N
Bombay Isl.	Arabian Sea	72	53 E	18	53 N
Borneo	Indian Ocean	114	0 E	2	0 N
Bornholm	Baltic Sea	15	0 E	55	15 N
Bourbon	Indian Ocean	55	30 E	20	52 N
Cape Breton Isl.	Atlantic Ocean	61	0 W	46	0 N
Britain (New)	Pacific Ocean	152	20 E	4	0 S
Buen Ayre	Caribbean Sea	68	0 W	12	15 N

		Long.		Lat.	
Button Isl.	Hudson's Straits	65	19 W	60	35 N
Caldy Isles	British Channel	4	40 W	51	38 N
Caledonia (New)	Pacific Ocean	166	0 E	22	0 S
Canary Isles	Atlantic Ocean	17	0 W	28	30 N
Comora Isles	Indian Ocean	43	10 E	11	30 S
Candia	Mediterranean Sea	25	0 E	35	0 N
Capri	Mediterranean Sea	14	10 E	40	32 N
Carolinas	Pacific Ocean	146	0 E	9	30 N
Catherine's, St.	Atlantic Ocean	48	0 W	27	22 S
Celebes	Indian Ocean	120	0 E	2	5 S
Cephalonia	Mediterranean Sea	20	0 E	38	30 N
Ceram	Indian Ocean	129	0 E	3	23 S
Cerigo	Grecian Sea	23	0 E	36	0 N
Ceylon	Indian Ocean	80	50 E	7	50 N
Chagos Is.	Indian Ocean	72	30 E	6	0 S
Chiloe	Pacific Ocean	74	30 W	42	30 S
Cocos Isles	Indian Ocean	97	0 E	11	30 S
Corfu	Mediterranean Sea	19	56 E	39	38 N
Corsica	Mediterranean Sea	9	30 E	42	30 N
Cuba	Caribbean Sea	80	0 W	22	0 N
Curaçoa	Caribbean Sea	69	15 W	12	22 N
Cyprus	Mediterranean Sea	32	0 E	35	30 N
Dago	Baltic Sea	21	0 E	59	0 N
Da Maria Lajara	Pacific Ocean	158	0 W	28	0 N
Danger (Isle of)	Pacific Ocean	167	0 W	11	0 S
Delos	Grecian Sea	25	12 E	37	38 N
Desolation	Indian Ocean	69	0 E	49	0 S
Disco	Baffin's Bay	54	40 W	69	10 N
Dominica	Caribbean Sea	61	28 W	15	18 N
Domingo, St.	Caribbean Sea	70	0 W	19	0 N
Duke of York's	Pacific Ocean	173	24 W	8	41 S
Easter Isl.	Pacific Ocean	109	25 W	27	10 S
Elba	Mediterranean Sea	10	19 E	42	49 N
Eugano	Indian Ocean	102	17 E	18	35 N
Eustatia, St.	Caribbean Sea	63	5 W	17	29 N
Falkland Isles	Southern Ocean	59	30 W	52	0 S
Falster	Baltic Sea	12	0 E	54	0 N
Faro Isles	Baltic Sea	19	30 E	57	0 N
Feejee Isles	Pacific Ocean	177	0 E	16	30 S

		Long.		Lat.	
Felix & Ambrose	Pacific Ocean	80	30 W	25	30 S
Femerin	Baltic Sea	11	5 E	54	30 N
Fernanda Po	Gulf of Guinea	7	36 E	3	6 N
Ferro Isles	Atlantic Ocean	6	45 W	61	46 N
Flores Isl.	Indian Ocean	121	0 E	8	0 S
Formosa	Pacific Oeean	121	0 E	23	30 N
Friendly Islands	Pacific Ocean	174	46 W	21	9 S
Funen	Baltic Sea	11	0 E	56	0 N
Georgia Isl.	Atlantic Ocean	38	30 W	54	30 S
Gilolo	Pacific Ocean	128	7 E	0	0
Gore's Island	Sea of Anadir	172	30 W	60	40 N
Gothland	Baltic Sea	18	10 E	57	30 N
Gough's Is.	Atlantie Ocean	10	0 W	40	0 S
Grenada	Caribbean Sea	61	30 W	12	10 N
Guadaloupe	Caribbean Sea	61	45 W	16	0 N
Guernsey	English Channel	2	56 W	49	30 N
Guinea (New)	Pacific Ocean	140	0 E	5	0 S
Hanover (New)	Pacific Ocean	149	50 E	2	31 S
Hainan	Chinese Sea	109	30 E	19	0 N
Hebrides	Atlantic Ocean	6	30 W	57	0 N
Hebrides (New)	Pacific Ocean	167	0 E	15	0 S
Helena, St.	Atlantic Ocean	6	0 W	16	0 S
Heligoland	Atlantic Ocean	7	55 E	54	11 N
Holland (New)	Pacific Ocean	135	— E	25	— S
Horchilla	Caribbean Sea	67	30 W	12	0 N
Howe's	Pacific Ocean	158	0 E	31	30 S
Hyerres	Mediterranean Sea	6	25 E	43	0 N
Iceland	Atlantic Ocean	20	0 W	65	0 N
Isabel Mendana	Pacific Ocean	159	0 E	10	0 S
Ireland (New)	Pacific Ocean	152	0 E	3	0 S
Ivica	Mediterranean Sea	1	25 E	39	30 N
Japan Isles	Pacific Ocean	136	0 E	35	30 N
Jamaica	Caribbean Sea	78	0 W	18	15 N
Java	Indian Ocean	110	0 E	7	30 S
Jersey	English Channel	2	14 W	49	25 N
Jesso	Pacific Ocean	142	30 W	41	0 N
John's, St.	Gulf St. Lawrence	64	0 W	46	30 N
John's, St.	Pacific Ocean	128	0 E	7	0 N
Juan Fernandez	Pacific Ocean	77	0 W	33	30 S
Kingsmill's Group	Pacific Ocean	175	0 E	1	0 S

		Long.		Lat.	
Kurile Isles	Pacific Ocean	153	0 E	48	0 N
Laaland	Baltic Sea	11	30 E	54	30 N
Lacadive Isles	Indian Ocean	72	30 E	11	0 N
Ladrone Isles	Pacific Ocean	146	0 E	16	30 N
Langeland,	Baltic Sea	11	0 E	55	0 N
Lemnos	Grecian Sea	25	30 E	40	0 N
Lewis Isl.	Atlantic Ocean	6	32W	58	34 N
Lipari Isles	Mediterranean Sea	14	30 E	38	30 N
Laffoden Isles	Northern Ocean	13	0 E	71	0 N
Lombock	Indian Ocean	115	0 E	8	30 S
Loo Choo Isles	Pacific Ocean	129	0 E	28	0 N
Low Isles	Pacific Ocean	142	0W	16	0 S
Lucia, St.	Caribbean Sea	61	0W	14	0 N
Luconia	Pacific Ocean	122	0 E	17	0 N
Lundy Island	Atlantic Ocean	4	38W	51	10 N
Madagascar	Indian Ocean	47	0 E	19	0 S
Madeiras	Atlantic Ocean	16	0W	32	0 N
Madura	Indian Ocean	113	0 E	7	0 S
Majorca	Mediterranean Sea	3	0 E	40	0 N
Maldives	Indian Ocean	74	0 E	5	0 N
Malta	Mediterranean Sea	15	0 E	35	15 N
Man (Isle of)	Irish Sea	4	36W	54	18 N
Mariegalante	Caribbean Sea	61	0W	16	0 N
Marquesas Isles	Pacific Ocean	140	0W	8	10 S
Martinque	Caribbean Sea	61	16W	14	44 N
Martin's, St.	Caribbean Sea	63	0W	13	20 N
Matthew's, St.	Atlantic Ocean	7	30W	2	0 S
Mauritius	Indian Ocean	57	0 E	20	0 S
Melville	Northern Ocean	111	30W	75	30 N
Middleton's Isles	Pacific Ocean	158	— E	28	30 S
Milo	Grecian Sea	25	6 E	36	41 N
Minorca	Mediterranean Sea	4	0 E	40	0 N
Moen	Baltic Sea	12	30 E	56	0 N
Molucca Isles	Indian Ocean	127	0 E	3	0 S
Montserrat	Caribbean Sea	61	34W	16	54 N
3 Mountains (I. of)	Pacific Ocean	76	15W	46	0 S
Mysol	Pacific Ocean	130	0 E	2	0 S
Myteline	Grecian Sea	25	0 E	39	0 N
Navigators' Isles	Pacific Ocean	170	0W	14	30 S

		Long.		Lat.	
Naxia	Grecian Sea	24	25 E	36	30 N
Negropont	Grecian Sea	24	8 E	38	30 N
Nevis	Caribbean Sea	62	50W	17	14 N
Newfoundland	Atlantic Ocean	56	—W	69	— N
Nicobar Isles	Indian Ocean	94	— E	9	— N
Noirmoutier	Bay of Biscay	2	14W	47	— N
Norfolk Island	Pacific Ocean	168	30 E	29	10 S
Northern Archip.	Pacific Ocean	180	—	53	0 N
Nova Zembla	Northern Ocean	65	0 E	74	0 N
Oeland	Baltic Sea	17	0 E	57	0 N
Oesel	Baltic Sea	22	30 E	58	30 N
Oleron	Bay of Biscay	1	10W	45	50 N
Orkney Islands	Atlantic Ocean	2	36W	59	10 N
Ormus Island	Gulf of Persia	55	0 E	27	0 N
Otaheite	Pacific Ocean	149	30W	17	30 S
Owhyhee	Pacific Ocean	156	0W	20	0 N
Paros	Grecian Sea	25	44 E	37	8 N
Patmos	Grecian Sea	26	24 E	37	24 N
Paul's, St., Island	Indian Ocean	77	30 E	37	15 S
Pelew Isles	Pacific Ocean	134	30 E	7	0 N
Philippine Isl.	Pacific Ocean	120	0 E	12	30 N
Pitcairn's Isl.	Pacific Ocean	133	30W	24	30 S
Porto Rico	Caribbean Sea	67	4W	18	29 N
Powell's Group	Atlantic Ocean	46	0W	60	30 S
Prince Edwd.'s Is.	Indian Ocean	38	0 E	46	30 S
Princes Isles	Atlantic Ocean	7	26 E	1	41 N
Pr. of Wales' Arch.	Pacific Ocean	134	0W	56	0 N
Qn. Charlotte's Is.	Pacific Ocean	132	30W	54	30 N
Re (Island of)	Bay of Biscay	1	10W	46	10 N
Rhodes	Grecian Sea	27	30 E	36	15 N
Rugen	Baltic Sea	15	0 E	54	30 N
Sagaleen	Sea of Okotsk	143	0 E	51	0 N
Sambawa	Indian Ocean	118	0 E	8	30 S
Samos	Grecian Sea	27	0 E	37	30 N
Sandalwood	Indian Ocean	120	0 E	10	0 S
Sandwich Islands	Pacific Ocean	155	30W	20	30 N
Sandwich Land	Atlantic Ocean	27	45W	59	0 S
Santa Cruz	Pacific Ocean	165	0 E	11	0 S
Santorin	Mediterranean Sea	25	30 E	36	0 N
Sapienza	Mediterranean Sea	21	35 E	36	30 N

		Long.		Lat.	
Sardinia	Mediterranean Sea	9	30 E	40	30 N
Seychelle Isles	Indian Ocean	54	0 E	5	0 S
Scarpanto	Grecian Sea	27	0 E	35	45 N
Scilly Island	Pacific Ocean	155	30W	16	38 S
Scilly Islands	English Channel	6	41W	49	56 N
Scio	Grecian Sea	25	45 E	38	0 N
Sicily	Mediterranean Sea	15	0 E	38	0 N
Shetland Isles	Atlantic Ocean	1	1W	60	17 N
Society Isles	Pacific Ocean	152	0W	11	30 S
Socotra	Indian Ocean	54	0 E	12	30 N
Solomon's Isles	Pacific Ocean	159	0 E	9	0 S
South Shetland Is.	Atlantic Ocean	60	0W	62	0 S
Spitzbergen	Northern Ocean	14	30 E	78	0 N
Stromboli	Mediterranean Sea	15	40 E	38	40 N
Sumatra	Indian Ocean	101	0 E	0	0
Sunda Isles	See Barneo, Java,	&c. &c.			
Syro	Mediterranean Sea	24	30 E	38	30 N
Tenedos	Grecian Sea	26	0 E	39	40 N
Teneriffe	Atlantic Ocean	17	0W	28	18 N
Terra del Fuego	Pacific Ocean	70	0W	54	30 S
Thasos	Grecian Sea	24	32 E	41	0 N
Thomas, St.	Gulf of Guinea	8	0 E	0	0
Thomas, St.	Caribbean Sea	64	50W	18	22 N
Tigers Isles	Pacific Ocean	120	0 E	7	0 S
Timor	Indian Ocean	124	0 E	10	23 S
Tobago	Caribbean Sea	60	30W	11	10 N
Tortuga	Caribbean Sea	64	46W	11	16 N
Trinidad	Atlantic Ocean	29	45W	20	0 S
Trinidad	Caribbean Sea	61	30W	10	0 N
Usedom	Baltic Sea	14	2 E	53	56 N
Ushant	Bay of Biscay	5	5W	48	28 N
Vancouver's Isles	Pacific Ocean	126	0W	50	0 N
Van Diemen's	Pacific Ocean	146	0 E	42	0 S
Verd (Cape de) Is.	Atlantic Ocean	24	0W	16	0 N
Vincent, St.	Caribbean Sea	64	0W	13	0 N
Virgin Islands	Carribean Sea	64	0W	18	30 N
Wight (Isle of)	English Channel	2	0W	50	24 N
Zealand (New) Is.					
North part	Pacific Ocean	177	0 E	39	0 S
South part	Pacific Ocean	170	0 E	43	0 S

SECTION II.

ON THE CIRCLES OF THE GLOBE.

1. What circles are described on the Terrestrial Globe? The equator, the meridians, the ecliptic, the tropical circles, and the polar circles.

2. Is not the horizon a circle of the globe? It is; and though necessarily placed at some little distance from the globe, it is supposed to touch the surface of it.

3. What is meant by a great circle of the sphere? A great circle is that whose plane passes through the centre of the sphere.

4. Are any of these you have mentioned great circles? Yes; the equator, the ecliptic, the horizon, and the meridian.

5. What are the other circles called? They are called small circles.

6. How may these circles be further distinguished? All great circles, howsoever drawn, bisect the sphere and each other: the small circles cut the sphere into unequal parts.

7. What is the equator? The equator is a great circle, drawn at an equal distance from each of the poles, and dividing the earth into the northern and southern hemispheres.

8. Which is the northern hemisphere? All the space between the equator and the north pole; the rest of the globe is the southern hemisphere.

9. How does the equator lie with respect to the axis of the earth? It is perpendicular to the earth's axis.

10. What is the meridian? A circle whose plane passes through the poles of the world: it

cuts the equator, and all its parallels at right angles.

11. Does it not cut the horizon also? Yes; it passes through the poles of the horizon, and through the zenith and nadir of all places on the surface of the earth.

12. How can one meridian pass through the zenith of every place? The number of meridians is infinite—one being supposed to pass through every point on the earth.

13. What is the horizon? The horizon is a great circle, dividing the earth and the whole expanse of the heavens into two hemispheres—the visible and the invisible. When the sun is above the horizon it is day, and when he is below it, it is night or twilight.

14. Do we not say there are two horizons? The great circle of which we have spoken is the rational horizon. The sensible or apparent horizon, like the rational, divides the visible from the invisible part of the sphere. It is the circle which determines that segment of the earth's surface over which the eye can reach.

15. Is there a great difference between those two horizons? If we consider their extent on the earth's surface, the difference is very great: but if we imagine them continued to the sphere of the fixed stars, they will appear to coincide, because, in comparison with the distance of that sphere, the earth's semi-diameter is a mere point.

16. What is the ecliptic? It is the great circle in which the sun makes his *apparent* annual progress among the fixed stars. It is the real path of the earth round the sun.

17. What are those points in which the ecliptic and the equator intersect each other? The equi-

noctial points. One is called the vernal equinox, and the other the autumnal equinox.

18. What angle does the ecliptic make with the equator? An angle of 23^0 28′; very nearly 23½ degrees.

19. What are the tropical circles? The tropics are two circles distant 23½ degrees from the equator; one lying to the north of that circle, and the other to the south.

20. How are they distinguished? That to the north of the equator is called the tropic of Cancer; that to the south, the tropic of Capricorn.

21. Where are the polar circles? The polar circles are situated near the poles, and parallel to the tropics and equator.

22. How far are they from the poles? One lies 23½ degrees from the north pole, and the other 23½ degrees from the south pole.

23. How are they distinguished? That near the north pole is called the arctic circle—the other is called the antarctic circle.

24. What are parallels of latitude? Any circle drawn parallel to the equator is a parallel of latitude. Several such circles are drawn on the terrestrial globe—every point on the earth has a parallel of latitude.

Point out the equator, the ecliptic, and all those circles just described.

DIVISIONS AND USE OF THE CIRCLES.

1. How is the circle divided? Every circle is supposed to have its circumference divided into 360 equal parts, called degrees; each degree consists of 60 equal parts, called minutes; and each minute of 60 equal parts, called seconds.

2. Are the circles on the terrestrial globe so

divided? The meridian, the equator, the ecliptic, and the horizon, are so divided and numbered.

3. How is the brazen meridian numbered? On one side the numbering begins at the equator and runs north and south to the pole; on the other side the numbers begin at the pole, and end at the equator.

4. What purpose does this answer? The numbers that increase towards the pole serve for finding the latitude of places; those which increase towards the equator serve for elevating the pole to any required height above the horizon.

5. What other purpose does the brazen meridian serve? It serves as a universal meridian; for, by turning round the globe, any place can be brought to it, and it then becomes the meridian of that place.

6. What do you mean by the first meridian? It is the meridian from which the longitude of places is counted. It is usual in this country to reckon the longitude of places from the meridian that passes through the zenith of the observatory at Greenwich.

7. How is the equator numbered? The numbering commences at the first meridian, and increases to the right-hand side and to the left, until the numbers meet at the opposite side of the equator, where each amounts to 180°, or half the circumference of the globe.

8. Why is the equator so numbered? For finding the longitude of places.

9. What do those numbers indicate? Those that increase to the right shew *east* longitude, and those to the left *west* longitude.

10. How is the ecliptic numbered? The ecliptic is divided into 12 equal parts, called signs,

each of which contains 30^0: it is accordingly numbered from 1^0 to 30^0 in each sign.

11. What are those signs? The signs of the zodiac.

12. What is the zodiac? The space in which the planets perform their courses.

13. How is the ecliptic situated with respect to the zodiac? The ecliptic is situated within the centre of the zodiac, which extends to a distance of eight or nine degrees on each side of it.

14. Name those signs or constellations through which the ecliptic passes.

♈ Aries	♎ Libra
♉ Taurus	♏ Scorpio
♊ Gemini	♐ Sagittarius
♋ Cancer	♑ Capricornus
♌ Leo	♒ Aquarius
♍ Virgo	♓ Pisces

15. How are these signs placed on the ecliptic? The first six are in that part of the ecliptic which lies north of the equator, and are called the northern or summer signs—the other six are in the southern part of the ecliptic, and are called the southern or winter signs.

16. Are not four of these called cardinal signs? Yes; Aries, Libra, Cancer, and Capricorn.

17. Why are they called cardinal signs? They are the signs in which the seasons of the year severally commence. When the sun enters Aries, the spring commences; when he enters Cancer the summer; when he enters Libra, the autumn; and when he enters Capricorn, the winter.

18. How are these cardinal signs situated on the ecliptic? The sign Aries is at the vernal equinox; Cancer touches the northern tropic, which is thence

called the tropic of Cancer; Libra is at the autumnal equinox, and Capricornus is at the southern tropic, thence called the tropic of Capricorn.

19. Which are the solstitial points? The first degree of Cancer, and the first degree of Capricorn.

20. What two great circles pass through the equinoctial and solstitial points? The colures—one passing through the equinoctial points, is called the equinoctial colure; the other, passing through the solstitial points, is called the solstitial colure: both pass through the poles of the earth.

21. Then the colures divide the ecliptic into four parts? Yes; into four equal parts, each part containing three signs.

22. Has this division of the signs any reference to the seasons? It has. The spring season continues while the sun passes from Aries to Cancer; the summer, while he passes from Cancer to Libra; the autumn, while he goes from Libra to Capricorn; and the winter, while he proceeds from Capricorn to Aries.

Point out the divisions of the equator and meridian, and the 12 signs on the ecliptic.

23. How is the horizon divided and numbered? The wooden horizon of the artificial globe has been differently divided by different globe-makers; but, in the essential parts of the division, they all agree. The horizon of Cary's globe is divided as follows:— The first, or innermost circle, contains the degrees of amplitude; the next to it, the degrees of azimuth; the third circle contains the points of the mariner's compass; the next circle, the names and characters of the signs of the zodiac; the fifth circle contains the degrees of each sign; the sixth circle contains the days of the month, which arose

placed, that the sun's position in the ecliptic for any day can be readily found; the seventh and last circle contains the names of the twelve calendar months.

24. What uses does the horizon answer? It serves to determine the elevation of the pole, the rising and setting of the sun and the other heavenly bodies, as also their amplitude and azimuth.

25. Which are the cardinal points of the horizon? The four principal points of the compass—east, west, north, and south.

26. Which are the poles of the horizon? The zenith, or point of the celestial sphere exactly over head, and the nadir, which is the point diametrically opposite to the zenith.

Show those circles and points on the horizon.

THE ZONES.

1. What is a zone of the earth? A zone is a belt or division of the earth contained between two circles parallel to the equator.

2. How many zones are there? The whole surface of the earth is divided into five zones.

3. How are they named? The torrid zone, the two temperate zones, and the two frigid zones.

4. Where is each situated? The torrid zone is that portion of the earth's surface contained between the tropical circles. It extends to the distance of 23° 28′ on each side of the equator, and is therefore 46° 56′ broad.

The temperate zones extend from the tropics to the polar circles: that between the tropic of Cancer and the arctic circle is called the north temperate zone—the other is called the south temperate zone.

The frigid zones are those portions of the earth's

surface included within the arctic and antarctic circles: one is called the north frigid zone, the other the south frigid zone.

5. What is the breadth of the temperate and frigid zones? The temperate zones are each 43° 4′ broad; and the frigid zones each 46° 56′ broad, extending 23° 28′ from the pole on every side.

6. Why is the torrid zone so called? Because of its great heat, which is occasioned by the sun being always vertical within it.

7. Why are the zones about the poles called frigid? Because, in the polar regions the temperature is low, in consequence of the oblique direction in which the rays of the sun fall upon them; and the great length of their winter night.

8. Why are the other zones called temperate? Because they enjoy a medium temperature, having neither the excessive heat of the equatorial regions, nor the severe cold of the polar.

Point out the zones on the globe.

CLIMATES.

1. Did not the ancient geographers divide the surface of the globe into other zones than those we have mentioned? Yes; and these divisions they denominated climates.

2. What is the nature of those divisions? They are founded on the different lengths of the longest day. To take a particular instance. Suppose a person situated on a parallel of latitude where the longest day is 16 hours; if from that place he travel towards the pole until he arrive at a parallel of latitude where the longest day is 16½ hours, the space he has passed over is a climate.

3. Do all the climates from the equator to the pole change by this rule? No; this rule has re-

ference only to those climates between the equator and the polar circle. The longest day differs by a month in the climates which lie between the polar circle and the pole.

4. How many climates are there? There are 24 between the equator and the polar circle, and six between that circle and the pole; making 30 in each hemisphere—60 in all.*

OF LATITUDE.

1. The latitude of a place is its distance from the equator, or that arc of the meridian intercepted between the equator and the place.

2. Places situated on the equator have no latitude; for there latitude begins.

3. The greatest latitude any place can have is 90°: the poles alone have this latitude.

4. The difference of latitude between two places is their distance when referred to the same meridian.

5. When two places are situated on the same meridian, that which is nearer to the north pole is said to be *due* north of the other.

6. The farther any place is from the equator, the greater is its latitude.

OF LONGITUDE.

1. The longitude of a place is the segment of a circle parallel to the equator intercepted between the first meridian, and a meridian passing through the place.

2. Longitude is generally counted on the equator.

3. Places situated on the first meridian have no

* See Table of the Climates.

longitude. Places situated on the opposite meridian have 180°, which is the greatest distance a place can be from the first meridian.

4. All places on the same meridian have the same longitude.

5. Difference of longitude is an arc of a circle parallel to the equator, intercepted between the meridians of two places, showing how far one of the places is eastward or westward of the other.

POINTS.

1. The equinoctial points are those in which the ecliptic and equator intersect.

2. The solstitial points are those points of the ecliptic which touch the tropics.

3. The zenith is the vertical point of the heavens, or that point exactly over one's head.

4. The nadir is that point directly opposite to the zenith; or it is that point which would be cut by a line drawn from our feet through the centre of the earth, and produced to the celestial sphere.

5. The poles of a circle are two points, each situated 90° from the circumference of the circle. Hence the poles of the world are the poles of the equator.

The zenith and nadir are the poles of the horizon, either rational or sensible.

Cardinal Points.

6. The cardinal points in the heavens are, the zenith, the nadir, and the points on which the sun rises or sets.

7. The cardinal points of the ecliptic are the equinoctial points and the solstitial points.

8. The cardinal points of the compass, or horizon, are north, south, east, and west.

A Table of Degrees and Minutes to every Quarter Point of the Compass.

North.	South.	H. M.	Points	° ′ ″	Points	H. M.	South.	North.
		0 11	0¼	2 48 45	0¼	11 49		
		0 22	0½	5 37 30	0½	11 37		
		0 34	0¾	8 26 15	0¾	11 26		
N by E	S by W	0 45	1	11 15 0	1	11 15	S by E	N by W
		0 56	1¼	14 3 45	1¼	11 4		
		1 7	1½	16 52 30	1½	10 52		
		1 19	1¾	19 41 15	1¾	10 41		
NNE	SSW	1 30	2	22 30 0	2	10 30	SSE	NNW
		1 41	2¼	25 18 45	2¼	10 19		
		1 52	2½	28 7 30	2½	10 7		
		2 4	2¾	30 56 15	2¾	9 56		
NEbyN	SW by S	2 15	3	33 45 0	3	9 45	SEbyS	NWbyN
		2 26	3¼	36 33 45	3¼	9 34		
		2 37	3½	39 22 30	3½	9 22		
		2 49	3¾	42 11 15	3¾	9 11		
NE	SW	3 0	4	45 0 0	4	9 0	SE	NW

North.	South.	H. M.	Points	° ' "	Points	H. M.	South.	North.
		3 11	4¼	47 48 45	4¼	8 49		
		3 22	4½	50 37 30	4½	8 37		
		3 31	4¾	53 26 15	4¾	8 26		
NEbyE	SWbW	3 45	5	56 15 0	5	8 15	SEbyE	NWbyW
		3 56	5¼	59 3 45	5¼	8 4		
		4 7	5½	61 52 30	5½	7 52		
		4 18	5¾	64 41 15	5¾	7 41		
ENE	WSW	4 30	6	67 30 0	6	7 30	ESE	WNW
		4 41	6¼	70 18 45	6¼	7 19		
		4 52	6½	73 7 30	6½	7 7		
		5 4	6¾	75 56 15	6¾	6 56		
EbyN	W by S	5 15	7	78 45 0	7	6 45	E by S	W by N
		5 26	7¼	81 33 45	7¼	6 34		
		5 37	7½	84 22 30	7½	6 22		
		5 9	7¾	87 11 15	7¾	6 11		
East	West	6 0	8	90 0 0	8	6 0	East.	West.

In the above figure the cardinal points are those marked with the single letters E. W. S., and the upper or N. point. By inspecting the other points it will be perceived that each of them takes its name from the cardinal points between which it is situated; thus the N.E. point is that which lies mid-way between the N. and the E.; the S.E. point, that which lies mid-way between the S. and the E.; and so on.

The mariner's compass is an instrument by which ships at sea are directed from one place to another. It is a representation of the horizon, and consists of a paper card, cut circular, and divided into degrees and points which are called rhumbs. Beneath the north and south line of this card a magnetic needle is fastened, which, turning on a finely pointed centre pin, carries the card round with it, by which

means the several points of the card are constantly directed to the corresponding points of the horizon, allowance being made for a variation in the needle.

The variation of the compass is the number of degrees between the true north point and that which is indicated by the north point of the magnetic needle.

The variation is itself variable; being different in the same place at different times, and in different places at the same time. It is, at present, about 26½ west at Dublin; that is, the north point of the magnetic needle tends westward of the meridian about 26½ degrees.

OF THE POSITIONS OF PLACES.

Besides the method of determining the positions of places which we derive from latitude and longitude, geographers have long been accustomed to use other distinctions with reference to the relative positions of different places on the earth's surface; such as,—

1st. *Distinctions from situation.*—These are the Antœci, the Periœci, and the Antipodes, (for which see problem 43.)

2nd. *Distinctions by the shadow at noon.*—These are Ascii, Amphiscii, Heteroscii, and Periscii.

1. The Ascii, or shadowless, is a term applied to those who live within the tropics; because these people, when the sun is vertical to them, (and he is every day vertical in some of those parts), appear to have no shadow at noon; for the sun being directly over them, their shadows will be cast under their feet.

2. The Amphiscii, are those whose shadows are cast in opposite directions at noon: these also are

resident within the tropics; for when the sun is in the northern signs, their shadows are projected towards the south, and when he is in the southern signs, their shadows are cast towards the north.

3. The Heteroscii, or those whose shadows are cast only in one direction at noon, are the inhabitants of the temperate zones; for the shadows of the inhabitants of the north temperate zone are always projected toward the north at noon, and those of the inhabitants of the south temperate zone are always directed southward at noon.

4. The Periscii, or those whose shadows are carried round in all directions, are they who live in the frigid zones; for when the sun is above their horizon, as they are carried round by the earth's rotation, their shadows are successively directed to every point of the compass.

3rd. *Distinctions by the bearing or direction of places with respect to each other.*—This is a distinction frequently used: thus we say one place lies north of another, or south of another; as the island of Cuba lies northward of Jamaica, Ireland lies to the west of England, &c.

Such distinctions are of a common and general kind, but they may be rendered proper and particular by assigning the exact distance and point of the compass at which one place lies from another, as when we say, the island of St. Mary bears from the Lizard S. 48° 11′ W. at the distance of 1164 miles.

PART II.

PROBLEMS ON THE TERRESTRIAL GLOBE.

Problem 1.

To find the latitude of a given place.

Count on the brass meridian the number of degrees the place lies from the equator; these degrees are its latitude.

Questions.

1. How do you know whether the latitude be north or south?
2. What is the greatest latitude a place can have?

Prob. 2.

To find the longitude of a given place.

Bring the place to the meridian, and count on the equator the degrees from the first meridian to the meridian passing through the place: those degrees are the longitude.

Quest.

1. How do you know whether the longitude be east or west?
2. What is the greatest longitude a place can have?

Exercises on the 1st and 2nd Probs.

What is the lat. and long. of Dublin? *Answer*, Lat. 53° 23′ N. long. 6° 20′ W.

Required the lat. and long. of Hamburgh. *Ans.* 53° 33′ N., and 9° 59′ E.

Required the longitude and latitude of each of the following places,—Berlin, Bagdad, Tripoli, Taragona, Cape Formosa, the Island of St. Helena, Island of Minorca.

Prob. 3.

To find those places which have the same latitude as a given place.

Bring the given place to the meridian, and note its latitude, turn the globe round, and all places which pass under the observed latitude are those required.

Quest.

What is given in this problem, and what is required to be done?

Do all places having the same latitude lie at the same distance from the equator?

Exercises.

1. What places have the same latitude as Madrid? *Ans.* Pekin, Samarcand, Naples, &c.
2. What places lie at the same distance from the equator as Dublin?
3. What places lie at the same distance from the poles as Paris?

Prob. 4.

To find those places which have the same longitude as a given place.

Bring the given place to the graduated edge of

the meridian; then, all the places that lie along that edge have the same longitude.

Quest.

1. Do all places that have the same longitude lie at an equal distance from the first meridian? *Ans.* No; they lie an equal number of degrees from it, but they are not all equally distant from it in miles.

2. Which of them are? *Ans.* Those only which are the same distance from the equator.

Exercises.

1. What places have the same longitude as the Island of St. Helena? *Ans.* Part of the Ivory Coast, the Scilly Islands, east coast of Ireland, west coast of the north of Scotland, and the Ferro Isles nearly.

2. Find those places which have the same longitude as Mecca, Cape Horn, and the Cape of Good Hope.

3. What place, in the same longitude as the Island of Otaheite, lies at the same distance from the equator?

4. What places lie on the same meridian as Valencia, in Spain?

PROB. 5.

To find any place on the globe having the latitude and longitude given.

First find the longitude on the equator (p. 2,) and bring it to the graduated edge of the meridian; then, keeping the globe steady, look for the given degree of latitude; under that degree you will find the required place.

Quest.

1. What is given here, and what is required to be done?*

Exercises.

1. What island lies in lon. 59° 41′ w., and lat. 13° n.? *Ans.* Barbadoes, in the Caribbee Islands.

2. What city is situated in long. 88½° e. and lat. 22½′ n.? *Ans.* Calcutta.

3. What places are situated under the following latitudes and longitudes respectively—

Lon.		Lat.
3° 13′ w.	......	55° 57′ n.
18 0 e.	......	59 0 n.
3 11 w.	......	56 0 n.
9 8 w.	......	38 42 n.
61 30 w.	......	10 30 s.

4. What place lies in 171 west long., and on the borders of the north frigid zone?

5. What bay lies under long. 15° e., and under the tropic of Capricorn?

6. Into what river was Vancouver sailing, when he was in long. 9° 54′ w., and lat. 52° 37′ n.?

PROB. 6.

To find the difference of latitude between two places.

(1.) Find the latitude of each place. (2.) If both places be on the same side of the equator, subtract the less latitude from the greater; but, (3.) If the places be on different sides, add their latitudes together.

Exercises.

1. Let it be required to find the difference of latitude between Dublin and Lisbon.

* A question that may be asked at the beginning of each problem.

The lat. of Dublin is .... 53° 23′n.
The lat. of Lisbon is .... 38 42 n.
and because the latitude of each is N., we subtract the less from the greater, and find the difference to be 14 41

2. Let it be required to find the difference of latitude between Leghorn and the Island of St. Helena.

The lat. of St. Helena is .... 15 55 s.
The lat. of Leghorn is .... 43 33 n.
and because the latitude of the one is north, and that of the other south, we add their latitudes together, and so find the difference of lat. to be 59 28

3. Find the difference of latitude between Paris and Petersburgh.

4. How much farther north is Moscow than Cairo?

5. What is the difference of latitude between Cape Comorin and Cape Clear?

6. Answer the following without reference to the globe,—

If one place be	8° n.	and another	18° n.	what is their difference of latitude?
	24 s.		6 s.	
	23 n.		10 s.	
	54 n.		12 n.	

Prob. 7.

To find the difference of longitude between two places.

This is performed in the same manner as the foregoing problem, only using longitude instead of latitude.

Exercises.

1. Required the difference of longitude between Cape St. Vincent in Portugal, and the Island of St. Vincent, one of the Caribbees. *Ans.* 52° 16′.

2. Required the difference of longitude between Valetta, in the Island of Malta, and Cape Trafalgar in Spain. *Ans.* 20° 30′.

3. Find the difference of longitude between Presburgh and Madrid.

4. Find the difference of longitude between St. Thomas's Island and Ascension Island.

5. If one place be	5° e.	and another	20° w.	what is their difference of longitude?
	12 w.		16 w.	
	28 e.		18 e.	
	14 w.		10 e.	

Prob. 8.

To find the distance between any two places.

Find by the quadrant* of altitude the number of degrees the places are asunder; multiply that number of degrees by 60 for geographical miles, or, if English miles be required, multiply by 69½.

Exercises.

1. Required the distance between London and the Cape of Good Hope. The number of degrees between those places, as shewn by the quadrant, is 88; these multiplied by 60 will give 5280 geographical miles; and multiplied by 69½ will give 6116 English miles for the answer.

* The quadrant of altitude is a thin slip of brass, graduated like the equator and so contrived as to screw on any part of the meridian.

2. How far is the Cape of Good Hope from Cape Horn?

3. How many geographical miles in length, and how many in breadth is Van Diemen's Land?

4. How far in English miles are the Madeira Islands from Bristol?

5. When Captain Cooke was in longitude 110° west, and latitude 27° south, how far was he from the isthmus of Panama?

Prob. 9.

To rectify the globe for the latitude of a place and for the zenith.

Elevate the pole, (the north pole, if the given place be north, or the south pole, if the place be south) as many degrees above the horizon as the place has degrees of latitude; and make the brass meridian coincide with the meridian of the place by the mariner's compass.

Exercises.

1. Rectify the globe for the latitude of Hobart-town, Leyden, and Revel.

2. Rectify the globe for the zenith of Madras, London, and Hanover.

Remark.

The zenith or uppermost point of the meridian, is always the same as the degree which is at the horizon, under the *elevated* pole. When you have rectified for the latitude of a place, if you bring the place to the meridian, it will then be at the zenith, and by screwing the quadrant over it, the globe is rectified for the zenith of that place.

Prob. 10.

A place (as suppose London) being given on the globe, and its distance from another place (suppose Petersburgh), it is required to find all places situated at the same distance from Petersburgh that London is.

Bring Petersburgh to the zenith (p. 9), screw the quadrant of altitude over it, and extend the quadrant to London; note the degree of the quadrant exactly over London, then turning the quadrant round, that degree will pass over all the places required.

Exercises.

1. What places are at the same distance from Buda as Berne is? *Ans.* Hanover, Wilna, Turin, &c.

Remarks.

The place which is brought to the zenith should be kept steadily there, during the performance of the problem.

The problem might be performed thus—Extend a pair of compasses from Petersburgh to London; then, keeping the leg in Petersburg stationary, turn the other round, and it will pass over the required places.

Prob. 11.

Given the latitude or longitude of a place, and its true distance from a given place, it is required to find the place whose latitude or longitude is given.

If the distance be given in miles, reduce them to degrees, and mark off those degrees on the quadrant of altitude, counting from 0; which done, place the 0 of the quadrant on the *given* place;

then, if the *latitude* be given, move the other end of the quadrant *eastward* or *westward* (according as the required place lies to the east or west of the given place), till the degrees of distance on the quadrant cut the given parallel of latitude; at the point of intersection is the required place. If the *longitude* be given, move the other end of the quadrant (0 being still on the given place) *northward* or *southward*, according as the required place is situated, till the degrees of distance cut the given longitude; and, as before, you have the required place at the point of intersection.

Exercises.

1. A place in longitude 3¼° west, and in north latitude is 290 geographical miles from Lisbon. What place is it? *Ans.* Madrid.

2. In east longitude, and latitude 33° 26′ north, lies an ancient city, at the distance of 4280 English miles from London. What city is it? *Answer.* Damascus.

3. There is a city and sea-port 1510 geographical miles from Quebec, and south-west of it; its longitude is 82° 20. What place is it?

Prob. 12.

*To find how many miles are in a degree of longitude, in any given parallel of latitude.**

Find by the quadrant, or a pair of compasses, the number of equatorial† degrees between two meridians (which are 15 degrees apart at the equator) in the given parallel; then, by the rule

* See the Table at page 37.

† Degrees equal to those of the equator; the degrees of the quadrant are such.

of proportion, as the number of degrees between those two meridians at the equator is to the number of degrees between them in the given parallel, so is 60 to the geographical miles, or 69½ to the English miles in each degree in that parallel.

Exercises.

1. Let it be required to find how many miles, geographical or English, make a degree in the parallel of 30.

By the quadrant it will be found, that two meridians which are 15° apart at the equator, are only 13° apart in the parallel of 30; so that, as 15° : 13° : : 60 : 52, the geographical miles, or, as 15° : 13° : : 69½ : 60·23 the English.

2. How many miles are in each degree of longitude, in the parallel which lies between the temperate and frigid zones?

3. How many miles in a degree in the parallel between the temperate and torrid zone?

4. How many miles in a degree of longitude in the latitude of Moscow?

Remarks.

Since 15 is to 60 in the ratio of 1 to 4, the answer may be found in geographical miles, by multiplying the degrees taken between the meridians by 4.

Geographical miles may be reduced to English miles, by multiplying by 69½, and dividing by 60.

In taking the distance between the meridians, the quadrant should be kept parallel to the equator, or to the nearest parallel of latitude.

Table shewing the number of geographical miles in a degree of longitude on any parallel of latitude.

Lat.	Miles.	Lat.	Miles.	Lat.	Miles.
0	60·00	31	51·43	62	28·17
1	59·99	32	50·88	63	27·24
2	59·96	33	50·32	64	26·30
3	59·92	34	49·74	65	25·36
4	59·85	35	49·15	66	24·40
5	59·77	36	48·54	67	23·45
6	59·67	37	47·92	68	22·48
7	59·55	38	47·28	69	21·50
8	59·42	39	46·63	70	20·52
9	59·26	40	45·96	71	19·53
10	59·09	41	45·28	72	18·54
11	58·89	42	44·59	73	17·54
12	58·69	43	43·88	74	16·54
13	58·46	44	43·16	75	15·53
14	58·22	45	42·43	76	14·52
15	57·95	46	41·68	77	13·50
16	57·67	47	40·92	78	12·48
17	57·38	48	40·15	79	11·45
18	57·06	49	39·36	80	10·42
19	56·73	50	38·57	81	9·38
20	56·38	51	37·76	82	8·35
21	56·01	52	36·94	83	7·31
22	55·63	53	36·11	84	6·27
23	55·23	54	35·27	85	5·22
24	54·81	55	34·41	86	4·18
25	54·38	56	33·53	87	3·14
26	53·93	57	32·68	88	2·09
27	53·46	58	31·79	89	1·05
28	52·97	59	30·90	90	0·00
29	52·48	60	30·00		
30	51·96	61	29·09		

PROB. 13.

To find at what rate per hour the inhabitants

of a given place are carried from west to east, by the earth's diurnal motion.

Find (by p. 12) how many miles make a degree of longitude in the latitude of the given place, and multiply those miles by 15.

Exercises.

1. At what rate per hour are the inhabitants of Dublin carried by the earth's diurnal rotation on its axis? *Ans.* 532½ geographical miles.

2. At what rate per hour are the inhabitants of Ispahan, of Rome, of Lima, and of Bergen, respectively, carried from west to east by the diurnal motion of the earth?

Remark.

The reason of multiplying by 15 is this: the whole circuit of the equator being 360°, the 24th part of it is 15°; so that 15° of the equator will pass any assigned meridian in one hour; we therefore multiply the miles in one degree by 15, to find how many miles are in 15 such degrees.

PROB. 14.

The hour being given at any place, to find what is the hour at any other place.

Bring the given place on the globe, and the given hour on the hour circle, to the meridian, then turn the globe till any other given place comes to the meridian, and the required hour will be at the meridian also.

Or, Find (by p. 7) the difference of longitude between the two places; convert this difference of longitude into time; then, if the place where the hour is sought lie to the east of that at which the

hour is given, *add* this time to the given hour, but if to the west, *subtract*.

Exercises.

1. When it is 5 o'clock at Hydrabad, what is the hour at Jeddo?

By the first method—Hydrabad and 5 o'clock on the hour circle being both brought to the graduated edge of the meridian, and the globe then turned till Jeddo comes to the meridian, it will be found that the time at the latter place is 4 minutes after 9 o'clock.

By the second method—The difference of longitude between the two places is 61°, equal to 4 hours and 4 minutes of time: now because Jeddo, the place at which the hour is required, lies to the east of Hydrabad, this time, 4 hours, 4 minutes, is to be added to the given hour 5, which makes the time at Jeddo 4 minutes after 9 as before.

2. What hour is it at Pekin, when it is 4 o'clock in the evening at London?

3. What is the hour at Paris, it being 12 at noon at Cape Horn?

4. There is a place, the longitude of which is 75° west, and another, the longitude of which is 156° west. What is the hour at the latter place, when it is 3 o'clock in the morning at the former?

Remark.

Difference of longitude may be reduced to time thus—Multiply the degrees by 4, and the product will be minutes, which divide by 60 for hours; multiply the minutes of longitude by 4, and the result will be seconds of time; thus—

Reduce 39° 43′ of longitude to time.

	39°	43′				
	4	4				
min.	156	172 sec.		H.	M.	S.
	156 minutes of time		=	2	36	0
	172 seconds of time		=	0	2	52
	39° 43′ of longitude		=	2	38	52

Prob. 15.

The hour being given at any place, to find at what place it is any other given hour.

Let the given place, and the hour given at that place, be brought to the meridian; then turn the globe till the other given hour comes to the meridian—the places which come to the meridian with it are those required.

Or,

(1.) Convert the difference of time between the given hours into degrees of longitude. (2) Bring the given place to the meridian, and note on the equator the point which the meridian cuts. (3.) From that point count the aforesaid degrees of longitude on the equator, (reckoning them eastward if the hour at the required places be later than the hour at the given place, if otherwise, count them westward). Bring to the meridian the point where the reckoning ends, and the required places will be seen along the meridian's edge.

Exercises.

1. Let it be required to find where it is 1 o'clock

in the afternoon, when it is 7 o'clock in the afternoon at Pekin.

If Pekin and the hour 7 be both set to the graduated side of the meridian, and the globe turned *eastward*, till 1 o'clock on the hour circle comes to the meridian, the following places will be seen near the meridian's edge, viz.—Ostrog, Bucharest, Adrianople, Scarpanto Island, and Bird Island. At each of these places it is the given hour, 1 o'clock, or very nearly so.

By the second method.—(1.) The difference of time between the hours given, viz., 1 o'clock and 7 o'clock, is 6 hours; which, converted into degrees of longitude, equal 90°. (2.) Pekin, the given place, being brought to the meridian, the equator will be cut in the 117th degree of east longitude. (3.) From this point those 90 degrees are to be counted *westward.* (4.) The point where the reckoning ends, which is 27° E., being brought to the meridian, the above-named places will be at the meridian's edge.

2. When it is 5 o'clock in the morn at London, at what places is it 10 o'clock in the morning, and at what places is it 2 in the afternoon?

3. In what longitude are those places situated, whose difference of time from London is two hours and a half? (two solutions.)

4. A ship sailing in the parallel of 15° 56′ south, arrives at a certain island, where it is found that the time is slower than the London time by 23 minutes; required the island?

5. What places have their time two hours faster, and what places have their time three hours slower than the time at Constantinople?

Remarks.

1. To understand what is meant by earlier and later time,—Observe, If there be any two places assumed, which are not on the same meridian, the place which lies more easterly will have the later hour. Let the more easterly place be E, and the more westerly W, and let their difference of longitude be 15°, equal to 1 hour of time. Because the sun's apparent motion is from east to west, he will come to the meridian of E first; it is then 12 o'clock there. In an hour after that time he arrives at the meridian of W, by which time it is 1 o'clock at E, while it is only 12 at W, and so on, the time being always farther advanced, or the hour later at the place which is more easterly.

2. To reduce hours and minutes of time to degrees and minutes of longitude. Reduce the given time to minutes, and divide those minutes by 4 for degrees; if there be a remainder, multiply it by 60, and divide by 4 for minutes.

PROB. 16.

To find the sun's place in the ecliptic for a given day.

Find the given day on the horizon, and opposite to it you will find the sign and degree of the ecliptic in which the sun is for that day; find the same sign and degree on the ecliptic, and that will be the sun's place for the given day.

Exercises.

1. Find the sun's place in the ecliptic for the 16th of June; and also for January 27th, March 25th, August 9th, May 12th, and July 18th.

PROB. 17.

The sun's place in the ecliptic being given, to find the day.

The day will be found on the horizon opposite the sun's place.

Exercises.

1. On what day is the sun in the 10th degree of ♒ Aquarius?

2. On what day is the sun in the 1st degree of ♋ Cancer?

3. On what days is the sun in the equinoctial points, viz. in the 1st degree of ♈ Aries, and 1st degree of ♎ Libra?

PROB. 18.

The sun's place in the ecliptic given, to find his declination.

Bring the sun's place to the meridian, and observe the number of degrees it is from the equator these degrees are its declination.

Exercises.

1. When the sun's place is 5° in ♌ Leo, required his declination? *Ans.* 19° north.

2. When the sun's place is 8° in ♉ Taurus, what is his declination?

3. When the sun is in the vernal equinox, required his declination?

4. Required the sun's declination for the 18th of April?

Quest.

1. Of how many kinds is the sun's declination?

Ans. Two; north declination, and south declination.

2. At what times of the year has the sun these declinations respectively? *Ans.* He has north declination from the 21st of March till the 23rd of September; being then in the northern signs: and his declination is south from the 23rd of September till the 21st of March, as he is then in the southern signs.

3. At what times has the sun his greatest and least declination? *Ans.* He has his greatest declination on the 21st of June, and on the 21st of December, being on those days at the tropics; and his least declination on the 21st of March and 23rd of September, being then in the equator. In the former case his declination is $23\frac{1}{2}°$; in the latter it is 0.

4. In what points of the ecliptic is the sun when at the tropics?

PROB. 19.

To rectify the globe for the sun's place and declination for any given day.

Part 1st—Bring the sun's place to the meridian, and set the hour circle to 12, and the globe is rectified for the sun's place.

Part 2nd.—Keep the sun's place at the meridian, and elevate the pole according to the declination.

Exercises.

1. Rectify the globe for the sun's place and declination for the following days, viz.,

March 17,	April 1,
June 25,	December 21,
August 20,	May 14.

Quest.

What do you mean by saying, "elevate the pole according to the declination?" *Ans.* To raise the *north* pole if the declination be *northward*, or the *south* pole if the declination be *southward.*

PROB. 20.

A place being given, and the month and day, to find the point of the compass on which the sun rises; and also the time of his rising on that day.

Rectify the globe for the latitude (P. 9), and sun's place (P. 19), then turn the globe till the sun's place comes to the eastern edge of the horizon—the point of the compass directly opposite the sun's place is that on which he rises on the given day; and the hour at the meridian, on the hour circle, is the *time* of his rising.

Exercises.

1. On the 5th of May at what hour does the sun rise to London, and on what point of the compass? *Ans.* He rises at 5½ o'clock, and on the E. by N. point of the compass.

2. On the 14th of March, at what hour, and on what point of the compass does the sun rise at Paris?

3. In the lat. of Quebec, at what hour, and on what point of the compass does the sun rise on the 1st of June?

Remarks.

1. If the time of the sun's setting be required, or the point of the compass on which he sets; proceed exactly in the same manner, only bringing the sun's place to the *western* side of the horizon.

2. If the hour of the sun's setting be doubled, it gives the length of the past day; if the hour of his rising be doubled, it will give the length of the past night.

3. This problem does not apply to places in the frigid zones.

Exercises.

4. On what point of the compass, and at what hour does the sun rise at Dublin on Michaelmas day? Required also, the time of his setting, and the length of the day and of the night?

5. Which is the shorter, the day at Lisbon, or the night at the Cape of Good Hope, on the 28th of August?

Prob. 21.

Given the month and day of the month, to find the sun's amplitude at any place.

Rectify the globe for the latitude of the place; find the sun's place for the given day, and turn it to the eastern side of the horizon: then, the degrees intercepted between the *East point* and the sun's place will be the sun's amplitude at *rising*; and the amplitude at setting may be found, by turning the sun's place to the *western* side.

Exercises.

1. Required the sun's amplitude in latitude 40° north, on the 5th of May? *Ans.* 22° 26'. north.

2. Find the sun's amplitude at the following places, on the given days:—At Dublin on the 1st of March, at London on the 21st of June, at Jersey, February 24th, at Boston, July 5th, at St. Helena, May 3rd.

Remarks.

1. The sun's true amplitude, as compared with his magnetic amplitude, is used at sea to find the variation of the compass.

2. The *true* amplitude is an arc of the horizon, comprehended between the true east or west point thereof, and the centre of the sun at rising or setting.

3. The sun's *magnetic* amplitude is his distance from the east or west point of the compass, as indicated by the magnetic needle.

4. The sun's true amplitude is always of the same name with the declination, whether north or south.

PROB. 22.

Given the latitude and sun's declination, to find the amplitude of the sun.

This problem may easily be understood from the foregoing, and shall be left to the ingenuity of the learner.

Exercises.

1. In latitude 51° 32′ N., the sun's declination being 10¾° S., required the sun's amplitude? *Ans.* 17½° S.

2. In latitude 38½° N., what is the sun's amplitude, the declination being 19° N?

3. In N. lat. 54½°, the sun's declination being 20° N., required the amplitude? *Ans.* 35½° N.

PROB. 23.

Given the sun's amplitude and the day of the month, to find the latitude of the place of observation.

Find the sun's place in the ecliptic for the given day; then look on the horizon for the given degree of amplitude; turn the sun's place towards that degree, and elevate or depress the pole, till the sun's place and amplitude coincide; the elevation of the pole is the required latitude.

Exercises.

1. On the 7th of August the sun's amplitude at rising was observed to be 19^0 from the east towards the north; in what latitude was the observation made? *Ans.* In 31^0 N.

2. The sun's amplitude at setting was observed to be $33\frac{1}{2}°$ from the west towards the north on the 19th of July; required the latitude of the place of observation? *Ans.* $49\frac{1}{2}^0$ N.

3. The sun, on the 10th of May, was observed to rise on the E. S. E. point of the compass; required the latitude?

4. On the 4th of September a ship arrived at a certain island, in longitude 164^0 E.; and the sun's amplitude being taken at setting was 7^0 from the W. towards the N.; required the latitude and the island?

Prob. 24.

The month, day, and hour of the day given, to find the sun's azimuth and his altitude at any place.

Rectify for the latitude and sun's place, (Probs. 9 and 18), screw the quadrant of altitude in the zenith; then, if the given hour be in the forenoon, turn the globe eastward; if in the afternoon, westward, as many hours as the given time is from noon; keep the globe from revolving, and make

the graduated edge of the quadrant, coincide with the sun's place. Count the degrees from the north or south point of the horizon to the graduated edge of the quadrant—they will be the azimuth; count the degrees of the quadrant which are between the horizon and the sun's place—they will be the altitude.

Exercises.

1. Required the azimuth and the altitude of the sun at Lisbon, on the 10th of March, at 11 o'clock in the forenoon?

By rectifying, &c., as directed in the problem, and turning the globe *eastward*, (because, in the forenoon hours the sun is to the *east* of the meridian), to 11 on the hour circle, the azimuth will be found to be 24° from the south, and the altitude, 45°.

2. What is the sun's azimuth, and what his altitude, at Cape Comorin at 2 o'clock in the evening, on the 12th of March?

The hour being one in the afternoon, the globe must in this case be turned *westward*. The answer is—Azimuth, 70° from the S., or 110° from the N. Altitude, 57¾°.

3. What is the sun's azimuth, and also his altitude, at Port Royal, on the 16th of April, at 7 o'clock in the forenoon?

4. What is the azimuth and altitude of the sun, in lat. 55° S. at 11 o'clock in the afternoon, on the 1st of August.

Questions.

1. What is meant by the azimuth of the sun? *Ans.* It is the arc of the horizon which is contained

between the meridian of a place, and a vertical circle passing through the centre of the sun.

2. What are vertical circles? *Ans.* Vertical, or azimuth circles, are great circles intersecting each other in the zenith and nadir, and cutting the horizon at right angles.

3. What is meant by the prime vertical? *Ans.* A vertical circle passing through the east and west points of the horizon.

4. In the performance of this problem, what represents the vertical circle passing through the sun? *Ans.* The quadrant of altitude.

5. What is meant by the altitude of any of the heavenly bodies? *Ans.* The height of such body above the horizon, counted on a vertical circle.

PROB. 25.

To find the sun's meridian altitude, a place, and the day of the month being given.

Rectify for the declination (P. 19), then bring the given place to the meridian, and count on the meridian the number of degrees from the place to the horizon the nearest way; the degrees so counted will be the sun's meridian altitude.

Exercises.

1. What is the sun's meridian altitude at Cape Horn, on the 17th of March? *Ans.* 35½°.

2. What is the meridian altitude at Mexico, on the 27th of August? *Ans.* 79½°.

3. What is the meridian altitude at Petersburg, on the 25th of June?

4. What is the sun's meridian altitude at Dublin, on the 7th of October?

Remarks.

1. The sun's *meridian* altitude is his height above the horizon at *noon*.

2. At the time of the equinoxes, the sun's meridian altitude at any place equals the complement of the latitude; that is, what the latitude wants of 90°.

3. If the place be in the torrid zone, the declination and latitude being known, the meridian altitude may be found without a globe, thus—

If the declination and latitude be both north, or both south, the sum of the declination and complement of the latitude taken from 180° will leave the meridian altitude.

If either the latitude or declination be north, and the other south, their sum, taken from 90°, will leave the meridian altitude.

Example.

Both North.
Lat. 20 N. Comp. 70
Dec. 23 N. ... 23

180 $\overline{93}$ =87 Mer. Alt.

One N. the other S.
Lat. 10 N.
Dec. 18 S.

90 — $\overline{28}$ =62 Mer. Alt.

4. In the temperate zones the following rule may be applied;—

If the lat. and dec. be of one name, add the co. lat.* to the declination.

If one be N. and the other S., subtract the declination from the co. lat., and in each case the result will be the meridian altitude.

* A contraction for *complement of the latitude.*

Example.

Same name.			Different name.		
Lat. 56 N.	co.	34	Lat. 32 S.	co.	58
Dec. 8 N.	...	8	Dec. 21 N.	...	21
	Mer. Alt.	42		Mer. Alt.	37

Prob. 26.

Given the sun's meridian altitude and the day of the month, to find the latitude of the place.

(1.) Find the degree of the sun's declination, for the given day (P. 18); count on the meridian from that degree, the given degrees of meridian altitude, (reckoning them northward, if the sun was north of the observer, or southward, if the sun was south of the observer, when the altitude was taken), and mark the point where the reckoning ends. (2.) Bring this point to the horizon, (to the N. point of the horizon if the mer. alt. has been counted northward, if otherwise, to the S. point), and the elevation of the pole will show the latitude.

Exercises.

1. On the 1st of July the sun's meridian altitude was observed to be 45°, and it was south of the observer; required the latitude of the place of observation? *Ans.* 68° N.

2. On the 29th of April the sun's meridian altitude was observed to be 50°, and the sun was north of the observer; in what latitude was the observer? *Ans.* 25° S.

3. On the 23rd of November, the sun's meridian altitude was observed to be 47°, and the sun was south of the observer; required the latitude?

Prob. 27.

The latitude of a place, and the sun's meridian altitude given, to find the day.

A knowledge of the foregoing problem will enable the learner to perform this, it being the converse of the former. We leave it to his ingenuity.

Exercises.

1. In lat. 68° N., when the sun's meridian altitude is 45° ; required the month and day?

2. In lat. 25° S., the sun's meridian altitude being 50°; required the day, or days?

Remark.

Two answers will be had to each question; but the reason of this will soon appear obvious.

Prob. 28.

To find the places to which the sun will be vertical on any given day.

Find the degree of the sun's declination for the given day; turn the globe round on its axis, and the places required will pass under that degree.

Exercises.

1. What places have the sun vertical on the 15th of April. *Ans.* The sun will be vertical, or nearly so, at the following places, viz., south of Abyssinia, Adel, C. Cambodia, Cliperton Rock, L. Nicaragua, G. of Darien, Trinidad I., &c.

2. What places have the sun in their zenith on the 10th of June?

3. What is the latitude of those places to which the sun will be vertical on the 18th of July?

4. How far are those places from the pole which have the sun in their zenith on the 21st of June?

Questions.

1. Which is the only zone to which the sun can be vertical? *Ans.* The torrid zone; because his greatest declination does not extend beyond the tropics.

2. During what months is the sun vertical between the equator and the tropic of Cancer? *Ans.* From March 21st to September 23rd.

PROB. 29.

A place in the torrid zone being given, to find the day or days on which the sun will be vertical at that place.

This, with one observation, we shall leave to the student.

Observation. The latitude of the given place will (upon turning round the globe) cut the sun's place in the ecliptic for the required day or days; and these may be found by Prob. 17.

Exercises.

1. On what two days of the year will the sun be vertical at Cape Comorin? *Ans.* April 10th, and September 1st.

At the I. of Mauritius, on what two days will the sun be vertical? *Ans.* January 18th, and November 23rd.

3. On what two days will the sun be vertical at Quito?

4. On what days will the sun be vertical at Bencoolen; at St. Helena; at St. Jago?

Prob. 30.

Given the month, day, and hour of the day at any place, to find to what part of the earth the sun is then vertical.

(1.) Mark off the sun's declination for the given day on the brass meridian; (2) find (by P. 15) on what meridian it is noon at the given hour; and on that meridian, exactly under the degree of declination, you will find the place to which the sun is vertical at the given hour.

Exercises.

1. When it is 24 minutes past 4 o'clock in the afternoon, on the 10th of May at London, where is the sun vertical?

Ans. (1.) The sun's declination for the 10th of May is 18° N. (2.) The meridian on which it is noon at the given hour lies 4h. 24m., or 66° to the west of London, (see *Remarks*, P. 15); this meridian being brought to coincide with the brass meridian of the globe, the degree of the sun's declination will be over Porto Rico, the required place.

2. On the 27th of March, when it is 8 o'clock in the forenoon at Dublin, where is the sun vertical?

3. What place has the sun in the zenith, when it is 9 o'clock in the evening, on a meridian lying 15° to the east of Quito, the day being the 12th of April?

4. On the 4th of September, when it is 5 o'clock in the afternoon, at 30° east longitude, where is the sun vertical?

Prob. 31.

To find those places to which the sun does not rise, and those places to which he does not set on a given day.

Find the declination, and rectify for it, (P. 19); turn the globe on its axis, and as it turns, observe those places which do not descend below the horizon, for to these the sun does not set on the given day. Next, observe those places which do not come above the horizon, for, to these the sun does not rise on that day.

Exercises.

1. Required the places to which the sun does not rise, and those to which he does not set on the 20th of August? *Ans.* To all places within 12½° of the N. pole the sun does not set on the given day; and to all places within 12½° of the S. pole, he does not rise on the given day.

2. Find those places to which the sun does not rise, and those to which he does not set on the following days, viz.,—June 21st, Dec. 21st, Aug. 1st, July 18th, and May 20th.

Remarks.

The following observations may, in some measure, explain why the sun does not rise to some parts of the earth, nor set to other parts on certain days.

1st. Place the poles of the globe in the horizon; the equator will then be in the zenith. This is the position of the earth with respect to the sun at the time of the equinoxes. As the sun's course at those times is in the equinoctial, all places on the earth from pole to pole will be enlightened when above the horizon—the sun rising to every part of the earth.

2nd. Let the sun be still supposed in the zenith, and elevate the N. pole a few degrees above the horizon, the S. pole will be as many degress de-

pressed; and as the sun enlightens at one time only those parts of the earth which are above the horizon, it is plain that the places about the depressed pole are not now enlightened, but that the sun's light has extended as far beyond the elevated pole as it has receded from the depressed pole. Elevate the N. pole to 23½°, and the globe will be in the same situation with respect to the sun, as the earth is at the time of the summer solstice, at which time it is obvious the sun's light must extend 23½° beyond the N. pole, while it is withdrawn as far from the S. pole. The contrary will take place at the time of the winter solstice, for the S. pole being then elevated 23½°, the sun's light will so far extend beyond it, and be withdrawn from the N. pole.

Prob. 32.

A day being given, to find what other day of the year is of the same length.

Find the degree of the sun's declination for the given day; turn the globe till some other point of the ecliptic passes under that degree of the meridian; find this point of the ecliptic on the horizon —the day required is opposite to it.

Exercises.

1. What day is of the same length as the 1st of May? *Ans.* The 14th of August.

2. What day is of the same length as the 14th of January?

Remarks.

1. From this problem it appears, that places on the same parallel of latitude have their day of the same length.

2. The problem may be readily wrought on the wooden horizon, thus, place one point of a pair of compasses on the given day, and extend the other point to the nearer solstice, the same extent will reach from the solstice to the required day.

Prob. 33.

To find the length of the day or night at any time, or in any latitude not within the frigid zones.

Having rectified for the latitude, bring the sun's place for the given day to the eastern side of the horizon; set the hour circle to 12 o'clock; turn the sun's place over to the western side, and the hours which pass the meridian will show the length of the day, which, taken from 24 hours, gives the length of the night.

Or,

Find the time of the sun's rising for the given day by Prob. 20, and then proceed as taught in the 2nd remark on that problem.

Exercises.

1. What is the length of the 2nd day of June, in lat. 54° N? *Ans.* 16½ hours.
2. What is the length of the day, and also of the night, on the 17th of October, in lat. 9° S.? *Ans.* The day 10½ hours. The night 13½ hours.
3. What is the length of the 16th of May at the Cape of Good Hope? *Ans.* 10⅕ hours, or 10h. 12m.
4. Find the length of the day and of the night in the following places, on the day given, with each place:—

At Lisbon, on the 5th of September.

At London, on the 12th of January.
At Petersburg, on the 2nd of May.
At latitude 30 S., on the 10th of August.
At Cork, on the 21st of June.

Remarks.

1. The finding the length of the *longest* or *shortest* day at places not in the frigid zones, is merely a particular application of this problem. To find the length of those days, it is only necessary to know, that the sun's place for the longest day is the 1st degree of Cancer, in the northern hemisphere; and for the shortest day, the 1st degree of Capricornus. Reverse these in the southern hemisphere.

2. When the length of the day is known, the time of sunrise or sunset can be determined. Half the length of the day gives the time of sunsetting, which, taken from 12 hours, will give the time of sunrise for that day.

PROB. 34.

The length of the longest day, at any place not in the frigid zones being given, it is required to find the latitude of that place.

If the place be in the northern hemisphere, being the first degree of Cancer to the meridian; if in the southern hemisphere, the 1st degree of Capricornus, and set the hour circle to 12; turn the globe westward till as many hours as are equal to half the given day have passed the meridian; keep the globe from revolving, and elevate or depress the pole till the first degree of Cancer, or Capricorn, (whichever was brought to the meridian), comes

to the horizon; the elevation of the pole will show the latitude.

Exercises.

1. In what latitude N., is the longest day 20 hours? *Ans.* 63° N.

2. In what latitude south, is the longest day 18 hours?

3. In what latitude N., does the sun set at 8 o'clock on the longest day?

4. In what degree of south latitude does the sun rise at 5 o'clock on the longest day?

5. In what degree of N. latitude is the 21st of June 22 hours long?

Prob. 35.

Given the latitude of a place, and the month and day, to find at what time the sun will be due *east or west on that day.*

Rectify the globe for the latitude of the place; bring the sun's place for the given day to the meridian, and set the hour circle to 12; screw the quadrant of altitude in the zenith, and bring it to the east point of the horizon; keeping the quadrant at the east point, turn the globe till the sun's place comes to the graduated edge of it; observe how many hours have passed the meridian: for just so many hours before noon, the sun will be due east, and so many after noon, he will be due west.

Exercises.

1. On the 1st of April, at what hour will the sun be due E. to London, at what time will he be due west, and what will be his altitude at those times? *Ans.* Due E. at a quarter past 6; due W., three-quarters past 5; and his altitude 7°.

2. At what time will the sun be due east, and at what time due west, in the latitude of Paris, on the 21st of March? Required also whether he is then due east to any other places, and what places they are?

3. Required the time at which the sun will be due east, and at which he will be due west at London, on the 27th of October. (*See Remarks.*)

Remarks.

1. If the sun's declination for the given day be of the *same* kind as the latitude, the sun will be due east and west while *above* the horizon; but, if of different kinds, not till he is below the horizon. In the latter case, find the point of the ecliptic which is diametrically opposite to that of the sun's place, and proceed as before.

2. The opposite point of the ecliptic may be found, by counting six signs from the sun's place.

PROB. 36.

To find the time at which morning twilight begins, or evening twilight ends, the place and day being given. (See Remarks).

Rectify the globe for the latitude of the given place, and also for the sun's place for the given day; screw the quadrant in the zenith; turn the sun's place and quadrant eastward, till the sun's place meets the 18°th of the quadrant below the horizon, the hour then at the meridian, on the hour circle, will show the time that *morning* twilight commences. To find the time that evening twilight ends, proceed in the same manner, only turning the quadrant and sun's place westward.

Exercises.

1. Required the time that morning twilight begins at Dublin, on the 4th of May, and also the time that evening twilight ends? *Ans.* The morning twilight begins at 39 minutes past 1 o'clock, and the evening twilight ends at 21 minutes past 10 o'clock.

2. At what time does the evening twilight end, and the morning twilight begin, at Lisbon, on the 5th of October?

3. How long after sunset does the twilight continue at Calcutta, on the 25th of November? how long is that night there? and what is the duration of the following morning twilight?

Remarks.

1. Twilight is that light which follows and precedes the sun, by reason of the refraction of the atmosphere. By its mild influence the sun's departure is gradually shaded off, and the abrupt advance of night prevented. In like manner it serves to modify the sun's approach, and mildly introduce the splendour of the day.

2. Twilight commences in the evening at the moment the sun sets, and continues to decline till he has descended 18° below the horizon, when it vanishes. It commences again in the morning when the sun comes within 18° of the horizon, and continues to increase in intensity till sunrise, when it ends.

3. The duration of twilight is shortest at the equator, and longest at the poles; its greatest continuance at the former being about 1¾ hours after

sunset, while at the latter it continues for nearly two months.*

4. Twilight is either constant or intermittent.

5. Constant twilight is that which takes place when the sun, from his setting to his rising, does not descend 18° below the horizon.

6. Intermittent twilight is that which takes place when the sun *does* descend 18° below the horizon, and a portion of night intervenes between the evening and the morning twilight. (*See next Problem.*)

PROB. 37.

A place being given, it is required to find whether twilight be always intermittent there, and if not, to find its duration when constant.

1*st Part.*—To the latitude of the given place add 18°, and subtract the sum from 90°; if the remainder be more than $23\frac{1}{2}$, twilight will be intermittent throughout the year at that place; if the remainder be less than $23\frac{1}{2}$, there will, during a part of the year, be constant twilight at the place.

2*nd Part.*—Having added 18° to the latitude, count the sum on the brass meridian from the pole, (that pole which is nearer the given place), towards the equator, mark the degree at which the reckoning ends; then turn the globe on its axis, and note the two points of the ecliptic which pass under that degree; find the days corresponding to those two points on the horizon, and the time between those two days will be the duration of constant twilight at the place.

* For the reason of this see Prob. 39.

Exercises.

1. Is there during any part of the year, constant twilight at Jerusalem; or, is the twilight there intermittent only?

The latitude of Jerusalem is	31°	46′
Add	18	00
Sum	49	46

From 90°
Take 49 46

Rem. 40 14

As this remainder is more than 23½ degrees, there will be no constant twilight at the given place; it will therefore be intermittent only.

2. Is twilight always intermittent at Dublin, or is it sometimes constant, and if so how long?

By proceeding as directed in the 2nd part of the problem, it will be found that the two points of the ecliptic cut by the degree on the meridian, viz. 71° 20′, (which is the latitude of Dublin, with 18° added) are 25° in Taurus, answering to the 15th of May, and 5° in Leo, answering to the 28th of July; so that from the 15th of May to the 25th of July, 74 days, there will be no real night, but a constant twilight while the sun is below the horizon. During the rest of the year, the twilight will be intermittent.

3. Is twilight at the following places intermittent only, or is it some time in the year constant? If constant, what is its duration at each place respectively? viz., Quito, Petersburg, Cape St. Lucas, Bern, London, Cape Horn.

4. When does constant twilight begin at Tornea, and what is its duration?

5. When does constant twilight begin at Liverpool, and what is its duration?

PROB. 38.

To find the duration of twilight at the north pole, also the length of the day and the length of the night.

By adding 18° to the latitude of the pole, we shall have 90°+18°, which counted on the meridian from the N. pole, will extend to the 18th degree south of the equator. Find what two points of the ecliptic will pass under this 18th degree; they will be found to be the 22nds. degree in ♏ corresponding with the 13th day of November, and the 9th degree in ♒, answering to the 29th of January. The southern portion of the ecliptic between these two points contains the period of dark night, equal to 77 days. The remainder of the ecliptic represents the length of the long day, together with the time of twilight. Now since the long day at the pole continues from the 21st of March to the 23rd of September, a period of 186 days, if to this number we add 77 days, we find the time of day and night taken together equal to 263 days, and taking these from 365 gives the duration of twilight, equal to 102 days.

So that their long day is	186	days,
The dark night	77	—
Duration of Twilight	102	—
Making in all ...	365	days.

Remarks.

1. From this problem it would seem, that the

inhabitants of the high polar latitudes have a very long and dreary night. We must not forget, however, that the moon, at that season, affords them a cheering light; continuing for half of each month above the horizon.

2. The Aurora Borealis also, in the northern regions, is singularly beautiful; and often diffuses a splendour equal to that of the full moon.

PROB. 39.

To illustrate the positions of the Sphere.

The positions of the sphere are three, viz., *Right*, *Parallel*, and *Oblique*.

For the Right Sphere. Place the poles of the globe in the horizon; the equator will then be at right angles with the horizon, as will also all the parallels to the equator: and hence, this position of the sphere is called a right or direct sphere.

For the Parallel Sphere. Place the poles in the zenith and nadir; the equator will then coincide with the horizon, and all the parallels to the equator will be parallel to the horizon also: for which reason this is called a parallel sphere.

For the Oblique Sphere. Elevate the pole to any distance or height less than 90°, and it will afford an illustration of the oblique sphere; for now the equator and its parallels are neither at right angles to the horizon, nor parallel to it, but are all cut obliquely by that circle.

Remarks.

1. Those only who live on the equator have a right sphere. To them, in whatever point of the ecliptic the sun may be, his diurnal course is at

right angles to the horizon; and since half of each parallel is above the horizon, and the other half below it, the day is at all times of the year equal to the night at the equator.

Also, because the sun's course is at right angles to the horizon, he takes a shorter time to arrive at the 18th degree of depression below the horizon, (see 3rd Rem., P. 36), and hence the twilights at the equator are comparatively short.

2. Those only who live at the poles have a parallel sphere. To an observer at the pole, the equator and horizon coincide, and the heavenly bodies appear to move round, either in the horizon, or parallel to it. Hence the sun is constantly above the horizon when he is on the same side of the equator with the pole, and constantly below it when on the other side; so that at either of the poles of the earth, there is but one day and one night in the year.

3. To the inhabitants of the N. pole, the sun sets on the 23rd of September, but, after he has set, his course being nearly parallel to the equator, a long time elapses before he arrives at the depression of 18°; and hence the twilight is favourably protracted.

4. Those who live at any part of the earth, except at the equator or the poles, have an oblique sphere. In this position of the sphere, the horizon cuts all the parallels of the equator unequally; and hence the days and nights are unequal at all places between the equator and the poles.

5. To perceive why the days and nights are unequal, let the N. pole be elevated 23½ degrees above the horizon, which is the sun's declination when the days are longest; then by inspecting the

parallels which lie between the equator and the tropic of Cancer, it will be seen that there is a greater portion of each parallel above the horizon than below it; and, as the sun's course from March to September is on some one of these parallels each day, it is plain that he will be longer above the horizon than below it on any day from March 21st, to September 23rd, to any place in north latitude.

PROB. 40.

To find how many days the sun rises or sets (as he does in the other zones) at any place in the frigid zone.

Find how many degrees the given place is from the pole, and count those degrees on the brass meridian from the equator, northward, and also southward; make marks where the reckonings end. Upon turning round the globe, two points of the ecliptic, one below Aries and the other above Aries, will pass under those marks; find on the horizon the days to which those points refer; during the time between those two days, the sun will rise and set as in the other zones every 24 hours. Observe, in like manner, the two points of the ecliptic above and below Libra, over which the marks on the meridian will pass; and find the two days to which they refer; during the interval between these days also, the sun will rise and set every 24 hours at the given place. If the days thus found, be added together, their sum will be the time sought.

Exercises.

1. During how many days in the year does

the sun rise and set at the I. of Disco, in lat. 69° 10′ N.?

The I. of Disco lies 20° 50′ from the pole, this being counted from the equator north and south on the meridian, the reckoning will end on 21 north and 21 south, very nearly. The two points nearest to Aries which pass under these marks are 26° ♑, and 4° in ♊, answering to the 16th of January and the 24th of May, between which are 128 days. The points nearest to Libra which will pass under the marks are 28° in ♋ and 3° in ♐, answering to the 20th of July and 25th of November between which are 128 days, making in all 256 days, during which time the sun will rise and set at the given place.

2. During how many days in the year does the sun rise and set at the North Cape, in lat. 71° 30′? *Ans.* 215 days.

3. How many days does the sun rise and set in lat. 75° N.

4. During how many days does the sun rise and set at C. Isabella at the north at Baffin's Bay?

Prob. 41.

To find the length of the longest day at any place in the north frigid zone, and also the length of the longest night.

Proceed exactly as in the foregoing problem, till you find the points of the ecliptic which pass under the marks; then the time between the two northern points will show the longest day at the place, and the time between the two southern points the length of the longest night. A reference to the former example will make this plain.

The two northern points of the ecliptic cut by the marks on the meridian were 4° in ♊ and 28° in ♋ between which there are 57 days during which the sun does not set to the Isl. of Disco, and which is therefore equal to their longest day. The southern points of the ecliptic which were cut are 3° in ♐ and 26 in ♑, between which are 52 days, the length of their longest night.

Exercises.

1. What is the length of the longest day, and of the longest night at the N. Cape, in lat. 71° 30′?

2. What is the length of the longest day and of the longest night at the North-East Cape, in lat. 78 North?

3. What is the length of the longest day and of the longest night at New Siberia, in latitude 74° North?

PROB. 42.

Given any day between the 21*st of March and the* 23*d of September, to find where, in the north frigid zone, the sun begins to shine constantly on that day.*

Find the sun's distance from the equator for the given day; count the same distance from the north pole towards the equator, and note the degree at which the reckoning ends; turn round the globe, and those places which pass under that degree are the places sought.

Exercises.

1. Required the latitude in which the sun begins to shine constantly on the 21st of April?

The sun's declination or distance from the equator is 12° N., wherefore, to all places lying 12° from the pole, or in lat. 78° N., he begins on that day to shine constantly.

2. To what places does the sun begin to shine constantly on the 15th of May?

3. In what latitude does the sun begin to shine constantly on the 3rd of August?

Remarks.

1. If the day given be between the 23rd of September and the 21st of March, the latitude at which the sun begins to shine constantly is near the south pole.

2. When the sun begins to shine constantly in any latitude in one of the frigid zones, he begins to be totally absent at the same latitude in the other frigid zone.

PROB. 43.

To find the Antœci Periœci and Antipodes to the inhabitants of any given place.

Place the poles of the globe in the horizon, and bring the given place to the eastern edge of that circle; observe how many degrees the place is from the east point, for so many degrees on the other side of the east point will be the place of its Antœci.

The Periœci will be found at the opposite side of the horizon, towards the same pole as the given place, but must be counted from the west point, to the same number of degrees.

The Antipodes will be found as near to the one pole as the given place is to the other pole, but at the opposite side of the horizon.

Exercises.

1. Required the Antœci, Periœci, and Antipodes to the inhabitants of the Island of Bermudas?

Ans. Their Antœci are situated in Paraguay, a little N.W. of Buenos Ayres; their Periœci in China, N.W. of Nankin; and their Antipodes in the south-west part of New Holland.

2. Find the Antœci, Periœci, and Antipodes to the inhabitants of London? Of Madras? Of Athens?

Remarks.

1. The Antœci are situated on the same meridian, but in opposite latitudes; they have contrary seasons, but the same hours.

2. The Periœci are situated on the same parallel of latitude, but in opposite longitudes; their seasons and length of day are the same; their hours contrary.

3. The Antipodes are situated diametrically opposite to each other, having longitudes, latitudes, seasons, days, and nights all contrary.

PROB. 44th.

A place being given, it is required to find in what climate it is situated.

Find the length of the longest day in the given place (1st rem. p. 33), subtract 12 hours from it, and the half hours in the remainder will be the number of the climate.

If the given place be in the frigid zone, divide the number of days contained in the longest day there by 30, and add the quotient to 24; the sum will be the number of the climate; if after dividing by 30 there be a remainder, count one climate more.

Exercises.

1. In what climate is Dublin?

Ans. 10th climate.

2. In what climate is Kola in Russia?

Ans. It is in latitude 68° $52'$, and in the 25th climate.

3. In what climate is Lima?

4. In what climate is Winter Harbour, in the Isle of Melville, latitude $74\frac{1}{2}$?

PROB. 45.

To find the breadths of the several climates between the equator and the polar circles.

Elevate the north pole $23\frac{1}{2}^\circ$ above the north point of the horizon; bring the first degree of Cancer to the meridian, and set the hour circle to 12; turn the globe eastward on its axis, till a quarter of an hour has passed the meridian, observe the point of the meridian passing through Libra which is cut by the horizon, and mark the point of intersection; continue the motion of the globe eastward, till another quarter hour has passed the meridian, and make a mark at the point of the aforesaid meridian then cut; proceed in the same manner till the meridian passing through Libra is no longer cut by the horizon in a different point. The distances between the several marks are the extents of the climates. The climates in the southern hemisphere may be similarly found.

Exercises.

1. What is the breadth of the 2nd climate?

Ans. 8° $10'$.

2. Required the breadth of the 21st climate?

3. What is the breadth of the 6th climate?
4. Find the breadth of the 8th climate?

TABLES OF THE CLIMATES.

1st. Climates between the Equator and the Polar Circles.

Climate.	Ends in latitude.	Where the longest day is.	Breadths of the climates.	Climate.	Ends in latitude.	Where the longest day is.	Breadths of the climates.
	D. M.	H. M.	D. M.		D. M.	H. M.	D. M.
I.	8 34	12 30	8 34	XIII.	59 59	18 30	1 32
II.	16 44	13 —	8 10	XIV.	61 18	19 —	1 19
III.	24 12	13 30	7 28	XV.	62 26	19 30	1 8
IV.	30 48	14 —	6 36	XVI.	63 22	20 —	— 56
V.	36 31	14 30	5 43	XVII.	64 10	20 30	— 48
VI.	41 24	15 —	4 53	XVIII.	64 50	21 —	— 40
VII.	45 32	15 30	4 8	XIX.	65 22	21 30	— 32
VIII.	49 2	16 —	3 30	XX.	65 48	22 —	— 26
IX.	51 59	16 30	2 57	XXI.	66 5	22 30	— 17
X.	54 30	17 —	2 31	XXII.	66 21	23 —	— 16
XI.	56 38	17 30	2 8	XXIII.	66 29	23 30	— 8
XII.	58 27	18 —	1 49	XXIV.	66 32	24 —	— 3

2nd. Climates between the Polar Circles and the Poles.

Climate.	Ends in latitude.	Where the longest day is.	Breadths of the climates.	Climate.	Ends in latitude.	Where the longest day is.	Breadths of the climates.
	D. M.	Dys. M.	D. M.		D. M.	Dys. M.	D. M.
XXV.	67 18	30 or 1	— 45	XXVIII.	77 40	120 4	4 35
XXVI.	69 33	60 2	2 15	XXIX.	82 59	150 5	5 19
XXVII.	73 5	90 3	3 22	XXX.	90 —	180 6	7 1

PROB. 46.

To find that part of the equation of time which depends upon the obliquity of the ecliptic.

Bring the sun's place for the day to the meridian,

and count the degrees between the first degree of Aries and the brass meridian, on the equator and on the ecliptic; the difference, reckoning 4 minutes of time to each degree, is the equation of time. If the number of degrees on the ecliptic exceed those on the equator, the sun is faster than the clock; but if the degrees reckoned on the equator exceed those counted on the ecliptic, the sun is slower than the clock.

Exercises.

1. What is the equation, so far as it depends on the obliquity of the ecliptic, on the 15th of February?

Ans. The equatorial degrees exceed those of the ecliptic by $2\frac{1}{4}$, so that the sun is 9 minutes slower than the clock.

2. What is the equation on the 2nd of September?

Ans. 6 minutes.

3. What is the equation on the 20th of March?

Remarks.

1. The difference of time, as shown by the sun and a well regulated clock, proceeds from two causes—viz., 1st, the obliquity of the ecliptic; and, 2nd, the sun's unequable motion: these sometimes combine with, and at other times counteract, each other. The present problem has relation only to the former, and therefore may not be taken as determining the true difference between *mean* and *apparent* time.

2. From the vernal equinox till the summer solstice, and from the autumnal equinox to the winter solstice, the first and third quarters of the year, the

time as shown by the sun-dial is in advance of that indicated by the clock; in the 2nd and 4th quarters the clock shows an advanced time, as compared with that indicated by the dial.

PROB. 47.

To construct a sun-dial by the globe.

Preliminary observations.

1. A sun-dial is a plane upon which hour lines are drawn, at such distances from each other as to suit the locality in which the dial is to be used.

2. The time is indicated on the dial-plane by a gnomon, or style, which represents the axis of the earth, and which is always placed parallel to it. The gnomon, by intercepting the sun's light, casts a shadow upon the proper hour.

3. If the plane upon which a dial is described, be parallel to the horizon, it is called a horizontal dial.

4. If the plane be perpendicular to the horizon, it is called a vertical dial. (There are many other kinds, but these two are the most useful.)

5 In the horizontal dial, the gnomon must stand on the plane at an angle equal to the latitude of the place for which the dial is constructed.

6. In the vertical dial, the gnomon must be placed at an angle equal to the complement of the latitude.

To make a horizontul dial for any latitude.

Elevate the pole, according to the given latitude, bring the first degree of Aries to the brass meridian, and keep the globe from revolving; then note the several points of the horizon intersected by the

meridians of the globe, (which meridians we suppose 15° apart); these intersections will show the hour distances for the dial-plane.

Example.

Let it be required to make a horizontal dial for the latitude of 54° north.

Elevating the north pole to 54° above the horizon, and proceeding as directed in the problem, the distances from the meridian for the several hours will be found to stand as follows, viz.:—

The distances for	XI. and I.	...	12°	15′
———————	X. and II.	...	25	2
———————	IX. and III.	...	38	58
———————	VIII. and IV.	...	54	30
———————	VII. and V.	...	71	40
———————	VI.	...	90	0

As it may be desirable to have more than those hours on the plane, lines may be drawn from any of those hours through the centre of the plane; such lines will cut the opposite side of the plane in the place of the corresponding hours: thus, if a line be drawn from VII., through the centre of the plane, it will point out the position of the opposite VII. The gnomon for this dial should form an angle of 54° with the plane, the angular point being placed at the centre of the plane, and the gnomon will then point directly to the north pole.

Prob. 48.

To make a direct south dial for any latitude (north).

Let it be required to make a direct south (vertical) dial for the latitude of London, 51½° north.

E 3

Rectify for the complement of the latitude, in the opposite hemisphere, that is $38\frac{1}{2}^{\circ}$ south; then proceeding as directed in the foregoing problem, the meridians before mentioned will be found to intersect the horizon as follows, viz.:—

For the hours	XI. and I. in	9°	28′
————	X. and II. —	19	45
————	IX. and III. —	31	54
————	VIII. and IV. —	47	9
————	VII. and V. —	66	42
————	VI. —	90	0

From the position of this dial, whose plane is in that of the *prime vertical*, it is clear that the sun cannot shine on it more than 12 hours, on any day; it will therefore be unnecessary and useless to find more than the above 12 hour-points on it.

The gnomon of this dial must make an angle with its plane equal $38\frac{1}{2}$ degrees, and point directly to the *south* pole.

Remarks.

1. The diversity of sun-dials arises from the different situation of the planes, and from the different figure of the surfaces upon which they are described; hence the different names arise, of *equinoctial*, *horizontal*, *vertical*, *polar*, *direct*, *erect*, *declining*, *inclining*, *reclining*, &c.

2. The time indicated by a dial must be adjusted to *true* time, by the table of equation, which may always be found in the Nautical Almanac, or White's Ephemeris.

PROB. 49.

To place the terrestrial globe in such a position in

the sun-shine, as to represent the natural position of the earth.

Place the globe due north and south, by the mariner's compass, so that the brass meridian shall coincide with the meridian of the place; and elevate the pole to the latitude; the globe will then correspond in all respects with the situation of the earth itself, and each great circle of the globe will be in the plane of its coincident circle in the heavens; and the continents, oceans, &c., marked on the surface of the globe, will be each turned towards the part of the earth where that is situated which it represents.

All the parts of the earth which are turned towards the sun, will be seen enlighted on the globe; and at one view the extent of day and night may be perceived.

If you find the parallel upon which the sun moves for the day, which is always under the degree of his declination, and move a pencil, &c., held upright, along it, till the shadow of the pencil falls under its base, you will have the point at which the sun is then vertical; this is the central point of the enlightened hemisphere; and if a line be drawn through it, from pole to pole, every place upon this line will have noon at that time; while all places to the *west* of it, will have *morning;* and all places to the *east* of it, *evening* or afternoon. Observe how far, on each side of the meridian to which the sun is vertical, his light extends; those situated on the western boundary of it, see the sun rising; those at the eastern boundary, see him setting.

Should the sun be in the equator, the enlightened hemisphere will terminate at the poles. If his

declination be northward, his light will be cast beyond the north pole, as many degrees as are equal to his declination; but, if his declination, at the time, be towards the south, his light will so far extend over the south pole, and will be withdrawn so far from the north pole as is his distance from the equator.

Prob. 50.

To illustrate, by the globe, the phenomena of the Harvest Moon.

The phenomena connected with the harvest moon admit of a most happy illustration, by either the terrestrial or celestial globe. They depend, principally, upon two circumstances.

1st. The different angles made by the horizon with the several parts of the moon's orbit.

2nd. The moon can be full but once or twice in the year, in those parts of her orbit which rise with the least angles.

On account of the obliquity of the ecliptic to the earth's axis, its several parts make very different angles with the horizon, as they rise or set. Those signs which rise with the least angles, set with the greatest, and *vice versa*. The less the rising angle, the greater is the portion of the ecliptic that rises in a given time. This will plainly appear, by elevating one of the poles to any considerable latitude, and turning the globe round on its axis.

For instance, in the latitude of London, at the time of the vernal equinox, when the sun is setting in the western part of the horizon, the ecliptic makes an angle of 62° with the horizon; but when the sun is in the autumnal equinox and setting at

the western side, the ecliptic makes an angle of only 15° with the horizon. Let us see how these circumstances affect the harvest moon.

Suppose the sun in the *vernal equinox*—Rectify the globe for the latitude (suppose of London) and also for the sun's place; bring the sun's place (the vernal equinox) to the western edge of the horizon; the hour at the meridian, on the hour circle, will then be VI.: at which time, let us suppose the moon to be in the autumnal equinox, consequently full, and rising exactly at the time of sun-set. By the following day, the sun will have advanced only about one degree in the ecliptic, and will set very nearly in the same time as before: not so the moon; she, in one day, at a mean rate, passes through 13° of her orbit; and therefore, on the day after the equinox, when the sun is setting, the moon will be below the horizon 13°; turn the globe till her place comes to the horizon, and the time of her rising, as shown by the hour-circle, will be 7h. 16m., an hour and quarter after the sun has set. On the following day she will be found to rise 2½ hours after sun-set; and so on, being each evening an hour and quarter later than the evening before, owing to the great angle which the ecliptic makes with the horizon at that part of her orbit.

Now, suppose the sun in the *autumnal equinox*, and the moon in the vernal; the globe being rectified as before, and turned till the sun's place comes to the western edge of the horizon, the meridian will indicate VI. for the time of sun-set, and also for the rising of the full moon on that day. On the following day the sun will set nearly at the same time, but the moon, having advanced 13° in the ecliptic, cannot rise so soon; but by turning

the globe till her place comes to the horizon, she will be found to rise about 17 minutes after sun-set. On the next day, she will rise about half an hour after sun-set; on the next, about three quarters of an hour, and so on; so that it will be near a week before the sun can be an hour set previous to the rising of the moon.

In higher latitudes this will appear still more striking.

Remarks.

1. In the problem, we have supposed that the moon's orbit coincides with the ecliptic; this will cause no sensible error, as their inclination is at an angle of only 5 degrees.*

2. The harvest moon, in north latitude, is the full moon which happens at, or near, the time of the autumnal equinox. In south latitude, it occurs at or near the time of the vernal equinox.

PROB. 51.

Given the time when a solar eclipse will occur, to find the places at which it will be visible.

Find, by problem 30th, the place to which the sun is vertical at the given time; bring that place to the zenith, by rectifying the globe for its latitude; then observe those places that are situated within 70 degrees of the zenith, for to that extent a solar eclipse will in general be visible.

Exercises.

If a solar eclipse take place on the 20th of Octo-

* Ferguson's Astron. Lect.

ber, when it is half-past eight o'clock in the morning at London, to what places would it be visible?

Ans. To all Europe, Africa, a great part of Asia, several of the East India isles, &c.

2. If an eclipse of the sun take place on the 6th of May, at half-past 12 at noon in Dublin, in what places will it be visible?

3. Suppose the sun eclipsed, when it is 2 o'clock in the afternoon at Dublin, on the 31st of December; to what parts of the earth will the eclipse be visible?

Prob. 52.

Given the time when a lunar eclipse will occur, to find the places at which it will be visible.

Find the antipodes to the place where the sun is vertical at the given time, bring it to the zenith; to all places then above the horizon the eclipse will be visible.

Exercises.

1. On the 31st of May, when it is 50 minutes after 10 o'clock in the afternoon at London, a total eclipse of the moon takes place; to what parts of the earth will it be visible?

Ans. The eclipse will be visible to all Europe and Africa, part of Asia, &c.

The moon will *rise* eclipsed to the inhabitants of the Carribbee Isles and the north-western parts of S. America. She will *set* eclipsed to the west of New Holland, the islands of Sumatra, Java, to Malacca, &c. She will be *vertically* eclipsed at the southern parts of Africa.

2. There will be an eclipse of the moon on the

24th of November, the middle of the eclipse will occur when it is 45 minutes after 11 in the afternoon at London; required the parts of the earth to which it will be visible?

Remarks.

1. An opaque body exposed to the sun's light casts a shadow behind it; there is therefore at all times a shadow cast from the earth and from the moon on the side remote from the sun.

2. If the moon at any time pass through the earth's shadow, the moon is thus deprived of the sun's light, and said to be eclipsed. This we call a lunar eclipse, because by it we are deprived of the moon's light.

3. If the earth pass through the moon's shadow, the earth is eclipsed; this we call a solar eclipse, because by it we are more or less deprived of the sun's light.

4. There can never be an eclipse of the sun except at the time of *new moon*.*

5. There can never be an eclipse of the moon except at the time of *full* moon.

6. As there is a full moon and a new moon every month, it may be asked, why should there not be an eclipse of the sun or moon every month? It would be so, if the plane of the moon's orbit coincided with that of the ecliptic; but these planes intersect each other in the line of the moon's nodes, and it

* "Hence it is proved that the darkness which took place at the time of our Saviour's crucifixion was not owing to an eclipse of the sun. The crucifixion happened at the time of the Jewish Passover, and the passover was, by law, to be celebrated at the time of *full* moon; the sun could not therefore be eclipsed at the time of the passover."

is only when the sun and moon are nearly in opposite nodes that an eclipse of the moon can take place; for in such case, the axis of the earth's shadow passes through the moon's centre, and there is then a total eclipse of the moon.

7. If the moon, when full, be within 12 degrees of the node she will be eclipsed, and the nearer she is to the node, the greater will be the eclipse. But if she be farther than 12° from the node, the earth's shadow falls above or below her, and in that case there can be no eclipse.

8. At the time of new moon, which is the only time that an eclipse of the sun can occur, the sun must be within 17 degrees of the moon's node, to cause an eclipse of the sun.

9. In an eclipse of the sun, the moon can cover only a small part of that luminary. Hence an eclipse of the sun is visible but to a few inhabitants of the earth at one time; and many parts of the earth suffer no eclipse, though the sun be above their horizon.

From the foregoing remarks (7 and 8) the following problem will be obvious.

Prob. 53.

To find the time of the year when the sun or moon will be liable to be eclipsed.

Find, from an Ephemeris, the place of the moon's nodes, the time of new moon, and the longitude of the sun; then, if the sun be within 17 degrees of the moon's node, there will be an eclipse of the sun. Again, find the place of the moon's nodes, the time of full moon, and the sun's longitude at the time; and if the sun's longitude be within 12 degrees of

the moon's node, there will be an eclipse of the moon.

PROBLEMS RELATING TO NAVIGATION.

Prob. 54.

*Given the difference of latitude and difference of longitude, to find the course and distance sailed.**

Example.

Admit a ship sails from a port, A, in latitude 38 degrees, to another port, B, in latitude 5 degrees, and finds her difference of longitude 43 degrees.

Let the port A be brought to the meridian, and elevate the pole to the given latitude of that port, 38 degrees, and fixing the quadrant of altitude precisely over it on the meridian, move the quadrant to lie over the second port, B, (found by the given difference of latitude and longitude,) then will it cut in the horizon 50° 45′, for the angle of the ship's course to be steered from the port A. Also, count the degrees on the quadrant between the two ports, which you will find 51 degrees; this number multiplied by 60, the nautical miles in a degree, will give 3060 for the distance run.

Exercises.

1. Suppose a ship sails from the port of Lisbon, in lat. 38° 42′ north, for the I. of Trinidad, in lat. 10° 30′ north, which differs in longitude from the former 52° 30′; required the course on which the ship must sail, and the distance between the ports?

* See *Martin* on the Globes.

Ans. She sails on a course of 72° 30′, and the distance of the ports is 54°, equal 3240 sea miles.

2. If a ship sail from Belfast, lat. 54° 36′ north, to an island in lat. 28° 17′ north, and there find her difference of longitude to be 10° 43′; required the island to which she sailed, and also the course, and distance?

Ans. She sailed to the I. of Teneriffe, her course was 20° and the distance 27½ degrees, equal 1650 geographical miles.

Remarks.

1. The line upon which a ship sails, or the point of the compass towards which she steers, is called her course; and the angle which this line makes with the meridian is also called the course, and is reckoned sometimes in degrees and sometimes in points of the compass; thus, a course of 22° 30′ and a N.N.E. course are the same.

2. If two places lie under the same meridian, the course from the one to the other is due north and south.

3. If two places lie under the equator, the course from one to the other is an arc of the equator, and is due east or west.

4. If two places lie under the same parallel, the course from one to the other is due east or west.

5. If two places lie neither under the equator, nor on the same meridian, nor in the same parallel, the most convenient course from one to the other is on a Rhumb, which, upon the globe, is a line so drawn as to cut all the meridians through which it passes at equal angles.

Prob. 55.

Given the difference of latitude and course, to find the difference of longitude, and distance sailed.

Example.

Admit a ship sails from a port, A, in 25 degrees north latitude, to another port, B, in 30 degrees south latitude, upon a course of 43 degrees.

Bring the port A, to the meridian, and rectify the globe to the latitude thereof, 25 degrees, fix the quadrant of altitude in the zenith, and place it so as to make an angle of 43° with the meridian, on the horizon, and observe where the edge of the quadrant intersects the parallel of 30° south latitude, for that is the place of the port B. Then count the number of degrees on the edge of the quadrant intercepted between the two ports, which will be found 73 degrees, which multiplied by 60, gives 4380 miles for the distance sailed. As the ports are now known, let each be brought to the meridian, and observe the difference of longitude on the equator, which will be found 50 degrees.

Exercises.

1. A ship sails from Monze, on the Malabar coast, in lat. 25° N. to a port in lat. 12° S., sailing on a course of 24° 30′ S.W.; required the port sailed to, the distance, and the difference of longitude?

Ans. The port is Cape Ambre, at the north point of Madagascar, the distance 2415 miles, and the difference of longitude 15° 48′.

2. A ship sails from Cape Comorin, in latitude 8° 5′ north, on a course of S. 65° 30′ E. to a place

in lat. 6° 48′ S.; required the place sailed to, the distance sailed, and the difference of longitude?

Ans. The place sailed to is Java Head; the distance, 1860 miles; and the difference of longitude, 27° 11′.

Prob. 56.

Given the difference of latitude, and the distance run, to find the difference of longitude and the angle of the course.

Example.

Let a ship sail from a port, A, in latitude 50°, to another port, B, in latitude 17° 30′, and the distance run be 2220 miles.

Rectify the globe for the latitude of the place A; reduce the distance run to degrees, these will be 37, and are to be reckoned from the end of the quadrant which is over the port A, at the meridian; move the quadrant till the 37 degrees will coincide with the parallel of 17° 30′ north latitude; then will the angle of the course appear in the arc of the horizon, intercepted between the quadrant and the meridian, which will be 32° 40′; and by marking the port B, and bringing it to the meridian, it will be found that the difference of longitude is 20 degrees.

Exercises.

1. A ship sailed from the Cape of Good Hope, lat. 34° 29′ south, to a place situated in lat. 55° 58′ south, and ran a distance of 3600 miles; required the place to which she sailed, the course, (which was between the south and the west,) and her difference of longitude?

Ans. She sailed to Cape Horn, on a course

S. 39° 30′ W., and her difference of longitude was 48° 58′.

2. From a port situated in latitude 16° 46′ N., a ship sails between the south and east, till her difference of latitude is 32° 41′; she runs a distance of 2250 miles; to what place does she sail, on what course, and what is her difference of longitude on her arrival?

Ans. The place is St. Helena; the course, S. 33 E.; and the difference of longitude, 19° 12′.

Prob. 57.

Given the difference of longitude and the course, to find the difference of latitude and the distance sailed.

Example.

Suppose a ship sails from A, in the latitude of 51°, on a course making an angle with the meridian of 40 degrees, till the difference of longitude be 20 degrees.

Rectify the globe to the latitude of the port A, place the quadrant of altitude so as to make an angle of 40 degrees with the meridian; then observe at what point it intersects the meridian which passes through the longitude of the port B, and there make a mark to represent that port; the number of degrees intercepted between that and the port A will be 28, which will give 1680 miles for the distance run; bring the mark B to the meridian, and its latitude will be 27° 40′.

Exercises.

1. Suppose a ship sails from Cape Florida, in lat. 25° 42′ N., and sailing between the south and

east, her course makes an angle with the meridian equal to 63° ; required her position, when her difference of longitude is 44° 26′ ; required also, the distance she has sailed and her difference of latitude?

Ans. Her position is at Cape St. Roque, at the N.E. point of South America. The distance she has sailed is 3210 miles, and her difference of latitude is 30° 48′.

2. A vessel sails from St. John's I. near Newfoundland, lat. 47½ N., and proceeds between N. and E. on a course of 64°, till her difference of longitude becomes 43° 30′ ; to what place and distance does she sail, and what is her difference of latitude at the end of her course?

Ans. She sails to Cape Clear on the south of Ireland, a distance of 28½ degrees or 1710 miles; and her difference of latitude is 3° 55′.

Prob. 58.

Given the course and distance sailed, to find the difference of longitude and difference of latitude.

Example.

Suppose a ship sails 1800 miles from a port, A, on an angle of 45°, to another port, B.

Having rectified the globe for the latitude and zenith of the port A, fix the quadrant of altitude over it, and bring the edge of the quadrant to the S.W. point of the horizon, 45° ; then upon the edge of the quadrant under 30 degrees (equal to 1800 miles from the port A) is the port B ; which being brought to the meridian, its latitude and longitude may be determined.

Exercises.

1. A vessel leaves Queen Charlotte's Sound, lat. 51° 4′ N., and sails on a course S. 44 W., to the distance of 2280 miles; required the place she is then at, and her difference of latitude and difference of longitude?

Ans. She is at the I. of Owyhee, one of the Sandwich islands; her difference of latitude is 30° 34′, and her difference of longitude, 27° 38′.

2. After a ship has sailed to a distance of 1830 miles from Cape Farewell, at the south of Greenland, on a course S. 66½ E.; required her position, her difference of latitude and difference of longitude?

Ans. She has arrived at Lisbon; and her difference of longitude is 36° 8′, and difference of latitude, 21 degrees.

Remarks.

In all these cases the ship is supposed to be kept upon the *arch of a great circle;* which may be done by frequently observing the latitude, noting the distance sailed, and finding, when it can be done, the difference of longitude; by means of these data, the course may be rectified from time to time throughout the voyage.

Except when a ship sails towards one of the cardinal points, it is necessary to change the course very frequently; for while she runs through different longitudes and latitudes, her horizon changes, and with it the bearing of the place to which she sails changes also: so that when two places lie one from the other towards a point not cardinal, if a ship sail from one of the places towards the point of the other's bearing, she will never arrive at that

other place. This may be illustrated by the globe, in the following manner.

Rectify the globe for any latitude in an oblique sphere (see prob. 39); bring any place, A, to the zenith, screw the quadrant over it, and extend the quadrant to any bearing—as, suppose, 40° on the horizon; take any two other places, B and C, along the edge of the quadrant, they will have the same apparent bearing as A; now rectify the globe for the latitude of B, which bring to the zenith, and screw the quadrant over it, causing it (the quadrant) to pass through C to the horizon: it will be found that the bearing now varies considerably from 40°; and if more places be taken, other variations may be observed.

PART III.

THE CELESTIAL GLOBE.

SECTION I.

DEFINITIONS.

1. The celestial globe is an inverted representation of the heavens, on which the stars are marked, according to their several situations. The diurnal motion of this globe is from east to west, to represent the apparent diurnal motion of the sun and stars. The eye is supposed to be situated in the centre of this globe. It is, however, beyond the stars.

2. The *declination* of a star or planet, is its distance from the equinoctial northward or southward. When the sun is in the equinoctial he has no declination, and so it is with a planet. The greatest declination a planet can have is 30° 28′ north or south—a star can have 90°.

3. The *latitude of a star or planet* is its distance from the ecliptic, north or south, reckoned towards the pole of the ecliptic, on the quadrant of altitude. Some stars situated in or about the pole, have 90° of latitude, the planets have only 8°; the sun being always in the ecliptic has no latitude.

4. The longitude of a star or planet is reckoned by the degrees of the ecliptic, from the point Aries

round the globe. The sun's longitude on the celestial globe corresponds with the sun's place on the terrestrial globe.

5. The right ascension of the sun, or of a star, is that degree of the equinoctial which rises with the sun or star in a right sphere, and it is reckoned from the equinoctial point Aries, eastward round the globe.

6. Oblique ascension of the sun or of a star, is that degree of the equinoctial which rises with the sun or a star in an oblique sphere, and is likewise counted from the point Aries, eastward round the globe.

7. Oblique descension of the sun or of a star, is that degree of the equinoctial which sets with the sun or star in an oblique sphere.

8. The ascensional or descensional difference is the difference between the right and oblique ascension, or the difference between the right and oblique descension; and, with respect to the sun, it is the time he rises before six in the spring and summer, or sets before six in the autumn and winter.

9. The angle of position of a star is an angle formed by two great circles intersecting each other in the place of the star; the one passing through the pole of the equinoctial, the other through the pole of the ecliptic.

10. The poetical rising and setting of the stars, is so called because the ancient poets referred the rising of the stars to the sun.

When a star rose with the sun, or set when the sun rose, it was said to rise and set cosmically.

When a star rose at sun-setting, or set with the sun, it was said to rise and set achronically.

When a star first became visible in the morning,

after having been so near the sun as to be hid by the splendour of his rays, it was said to rise heliacally; and when a star first became invisible in the evening, on account of its nearness to the sun, it was said to set heliacally.

11. A constellation is an assemblage of stars on the surface of the celestial globe, circumscribed by the outlines of some assumed figure, as of a bull, a bear, a lion, &c. This division of the stars into constellations, directs us to any part of the heavens where a particular star is situated.

The constellations of the *zodiac* are twelve in number; the *northern* constellations forty-one, and the *southern* forty-six, making in the whole ninety-nine. The largest stars are called stars of the first magnitude; those of the sixth magnitude are the smallest that can be seen by the naked eye.

I. Constellations in the Zodiac.

No. of Stars.	*Names of the Constellations, and of the principal stars in each, with their magnitudes.*	*R.	D.
66.	Aries, *the Ram*, Arietis 2, ...	30	22 N
141.	Taurus, *the Bull*, Aldebaran 1, the Pleiades, the Hyades, ...	65	16 N
85.	Gemini, *the Twins*, Castor and Pollux, 1, 2,	111	32 N
83.	Cancer *the Crab*, ...	128	20 N
95.	Leo, *the Lion*, Regulus, or Lion's Heart, 1,	150	15 N
110.	Virgo, *the Virgin*, Spica Virginis 1, Vendemiatrix, 2, ...	192	5 N
51.	Libra, *the Balance*, ...	226	8 S
44.	Scorpio, *the Scorpion*, Antares 1, ...	244	26 S
69.	Sagittarius, *the Archer*, ...	285	35 S

* R. and D. denote the Right Ascension and Declination of the middle of each Constellation; by these, any constellation may be readily found on the globe.

		R.	D.
51.	Capricornus, *the Goat*, ...	310	20 S
108.	Aquarius, *the Water-bearer*, Scheat 3, ...	335	4 S
113.	Pisces, *the Fishes*, ...	5	10 N

II. The Northern Constellations.

That rise nearly in the east, and set nearly in the west, at London.

		R.	D.
71.	Aquilla, *the Eagle*, with Antinous, Altair 1,	295	8 N
10.	Equulus, *the Little Horse*, ...	316	5 N
11.	*Mons Mænalus, *the Mountain Mænalus*,†	225	5 N
8.	*Scutum Sobieski, *Sobieski's Shield*, ...	275	10 S
64.	Serpens, *the Serpent*, ...	235	10 N
74.	Serpentarius, *the Serpent-bearer*, Ras Alhagus 2, ...	260	13 N
7.	*Taurus Poniatowski, *Bull of Poniatowski*,	275	7 N

That rise to the north of the east, and set to the north of the west, at London.

		R.	D.
66.	Andromeda, Mirach 2, Almaach 2, ...	15	35 N
25.	Asterion et Chara, vel, Canes Venatici, *the Greyhounds*, ...	200	40 N
54.	Böotes, Arcturus 1, Mirach 3, ...	212	30 N
43.	Coma Berenices, *Berenice's Hair*, ...	185	26 N
21.	Corona Borealis, *the Northern Crown*, Alphacca 2, ...	235	30 N
18.	Delphinus, *the Dolphin*, ...	308	15 N
113.	Hercules, Cerberus, *the Three-headed Dog*, Ras Algethi 3, in the head of Hercules,	245	22 N
53.	Leo Minor, *the Little Lion*, Deneb 2. . .	150	35 N
21.	Lyra, *the Harp*, Vega 1, ...	283	38 N
6.	*Musca, *the Fly*, ...	40	27 N
89.	Pegasus, *the Flying Horse*, Markab 2, Scheat 2, ...	340	14 N
18.	Sagitta, *the Arrow*, ...	295	18 N
11.	Triangulum, *the Triangle*, ...	27	32 N
5.	Triangulum Minus, *the Little Triangle*, ...	31	29 N
35.	Vulpecula et Anser, *the Fox and Goose*,...	300	25 N

† Those marked with a star are the modern constellations.

The whole or greater part of these do not set in the latitude of London.

		R.	D.
66.	Auriga, *the Charioteer* or *Waggoner*, Capella 1, ...	75	45 N
58.	Camelopardalus, *the Cameleopard*, ...	68	70 N
55.	Cassiopeia, Schedan 3, ...	12	60 N
35.	Cepheus, Alderamin 3, ...	338	65 N
3.	*Cor Caroli, *Charles's Heart*, ...	191	39 N
81.	Cygnus, *the Swan*, Deneb Adige 1, ...	308	42 N
80.	Draco, *the Dragon*, Rastaben 2, ...	270	66 N
16.	Lacerta, *the Lizard*, ...	336	43 N
44.	Lynx, *the Lynx*, ...	111	50 N
59.	Perseus, Caput Medusæ, *Head of Medusa*, Algenib 2, Algol 2, ...	46	49 N
87.	Ursa Major, *the Great Bear*, Dubhe 2, Alioth 2, Benetnach 2, ...	153	60 N
24.	Ursa Minor, *the Little Bear*, Pole Star 2,	235	75 N

III. The Southern Constellations.

That rise nearly in the east, and set nearly in the west, at London.

14.	Canis Minor, *the Little Dog*, Procyon 1,	110	5 N
97.	Cetus, *the Whale*, Menkar 2, ...	25	12 S
84.	Eridanus, *the River Po*, Acherner 1, ...	60	10 S
60.	Hydra, Cor Hydra 1, ...	139	8 S
31.	Monoceros, *the Unicorn*, ...	110	...
78.	Orion, Bellatrix 2, Betelguese 1, Rigel 1...	80	...
41.	Sextans, *the Sextant*, ...	145	...

That rise to the south of the east, and set to the south of the west, at London.

3.	*Brandenburgium Sceptrum, *the Sceptre of Brandenburg*, ...	67	15 S
31.	Canis Major, *the Great Dog*, Sirius 1, ...	105	20 S
10.	*Columba Noachi, *Noah's Dove*, ..	85	35 S
9.	Corvus, *the Crow*, Algorab 3, ...	185	15 S
31.	Crater, *the Cup or Goblet*, Alkes 3, ...	168	15 S

		R.	D.	
14.	*Fornax Chemica, *the Furnace,*	42	30	S
19.	Lepus, *the Hare,*	80	18	S
3.	Machina Pneumatica, *the Air Pump,* ...	150	32	S
10.	Microscopium, *the Microscope,*	315	35	S
12.	*Officina Sculptoria, *the Sculptor's Shop,*	3	35	S
24.	Piscis Notius vel Australis, *the Southern Fish,* Formlhaut 1, ...	335	30	S
4.	*Pyxis Nautica, *the Mariner's Compass,* ...	130	30	S

The whole or greater part of these do not rise in the latitude of London.

11.	Apus, vel Avis Indica, *the Bird of Paradise,*	252	75	S
9.	Ara, *the Altar,*	255	55	S
64.	Argo Navis, *the Ship Argo,* Canopus 1,. .	115	50	S
35.	Centaurus, *the Centaur,*	200	50	S
10.	*Chamœleon, *the Cameleon,*	175	78	S
4.	*Circinus, *the Compasses,*	222	64	S
12.	Corona Australis, *the Southern Crown,* .	278	40	S
5.	*Crux, *the Cross,*	183	60	S
6.	*Dorado, or Xiphias, *the Sword Fish,* ..	75	62	S
8.	*Equuleus Pictorius, *the Painter's Easel*...	84	55	S
13.	*Grus, *the Crane,*	330	45	S
12.	*Horologium, *the Clock,*	40	60	S
10.	*Hydrus, *the Water-snake,*	28	68	S
12.	*Indus, *the Indian,*	315	55	S
24.	Lupus, *the Wolf,*	230	45	S
30.	Mons Mensæ, *the Table Mountain,* ...	76	72	S
4.	*Musca Australis, vel Apis, *the Southern Fly or Bee,*	185	68	S
12.	*Norma, vel Quadra Euclidis, *Euclid's Square,*	242	45	S
43.	*Octans Hadleianus, *Hadley's Octant,* ...	310	80	S
14.	*Pavo, *the Peacock,*	302	68	S
13.	*Phœnix, ...	10	50	S
8.	*Piscis Volans, *the Flying Fish,*	127	68	S
16.	*Praxiteles, vel Cela Sculptoria, *the Graver's or Engraver's Tools,*	68	40	S
10.	*Reticulus Rhomboidalis, *the Rhomboidal net,*	62	60	S

	R.	D.
12. *Robur Caroli, *Charles's Oak*, ...	159	50 S.
9. *Telescopium, *the Telescope*, ...	278	50 S
9. *Touchan, *the American Goose*, ...	359	66 S
5. *Triangulum Australe, *the Southern Triangle*, ...	238	65 S

To this catalogue have been added, *the Lapland Rein-deer*, *the Hermit*, *Herschel's Telescope*, *the Honor of Frederick*, and other names not yet sanctioned by general usage.

12. The *culminating point* of a star or planet, is that point of its orbit which on any given day is the most elevated. A star or planet is said to culminate when it comes to the meridian of any place; for then its altitude is greatest.

13. The *polar distance* of any celestial object is an arc of a meridian, contained between the centre of that object, and the pole of the equinoctial.

14. The *apparent* place of a planet is that part of the heavens in which it appears to be, when viewed from the surface of the earth.

15. The *true* place of a planet is that point at which it would be seen if viewed from the centre of the earth. The difference between the true and apparent position is called *parallax*. The fixed stars have no sensible parallax, because of their great distance from the earth.

16. The fixed stars are so called because they are observed to keep the same position with respect to each other.

17. The galaxy, or milky-way, is a luminous tract which seems to encompass the heavens. It varies in breadth from about 4 to 20 degrees, and is composed of an infinite number of small stars, which, by their joint light, occasion the whiteness

that we observe in a clear starlight night. Its course may be traced on the celestial globe, beginning at Cygnus, through Cepheus, Cassiopeia, Perseus, Auriga, Orion's Club, the feet of Gemini, part of Monoceros, Argo Navis, Robur Caroli, Crux, the feet of the Centaur, Circinus, Quadra Euclidis, and Ara, where it divides into two parts, which, after passing through the other intervening signs, meet again in Cygnus.

18. Nebulous, or cloudy, is a term applied to those stars which are less than the sixth magnitude. It is said that there are 2500 such in the constellation of Orion. Such also are the stars that form the milky-way.

19. The usual manner of denoting the stars in the several constellations, is by applying to them the letters of the Greek and Roman alphabets, setting the first Greek letter α to the principal star in each constellation, ϐ to the second in magnitude, γ to the third, and so on till the Greek alphabet is finished, and then a, b, c, &c., of the Roman; and should there be more stars in the constellation, the numbers 1, 2, 3, &c., are applied.

THE GREEK ALPHABET.

		Name.	*Sound*			*Name.*	*Sound.*
Α	α	Alpha	a	Ν	ν	Nu	nu
Β	β ϐ	Beta	b	Ξ	ξ	Xi	x
Γ	γ	Gamma	g	Ο	ο	Omicron	o *short*
Δ	δ	Delta	d	Π	π ϖ	Pi	p
Ε	ε	Epsilon	e *short*	Ρ	ρ ϱ	Rho	r
Ζ	ζ	Zeta	z	Σ	σ ς	Sigma	s
Η	η	Eta	e *long*	Τ	τ	Tau	t
Θ	θ ϑ	Theta	th	Υ	υ	Upsilon	u
Ι	ι	Iota	i	Φ	φ	Phi	ph
Κ	κ	Kappa	k	Χ	χ	Chi	ch
Λ	λ	Lambda	l	Ψ	ψ	Psi	ps
Μ	μ	Mu	mu	Ω	ω	Omega	o *long*

20. Planets are opaque bodies, similar to our earth, which move round the sun in certain periods of time, and shine, not by their own light, but by reflecting the light which they receive from the sun. They are distinguished into primary and secondary.

21. The primary planets regard the sun as their centre of motion. There are 11 primary planets, distinguished by the following names and characters, viz.:—

☿ Mercury.	♀ Venus.	⊕ the Earth.
♂ Mars.	⚶ Vesta.	⚵ Juno.
⚳ Ceres.	⚴ Pallas.	♃ Jupiter.
♄ Saturn.	♅ Uranus.	

22. The secondary planets, satellites, or moons, regard the primary planets as their centre of motion: thus the moon revolves round the earth, the satellites of Jupiter move round Jupiter, &c. There are 18 secondary planets. The earth has one satellite, Jupiter four, Saturn seven, and Uranus six.

23. The *Nodes* are the points in which the orbit of a planet intersects the ecliptic; that where the planet seems to ascend from the south to the north side of the ecliptic, is called the *ascending* or north node, and marked thus ☊ ; the other the *descending* node and marked thus ☋

24. *Aspect* of the stars or planets is their situation with respect to each other. There are five aspects, viz, ☌ Conjunction, when they are in the same sign and degree; ✱ Sextile, when they are two signs, or a sixth part of a circle distant; □ Quartile, when they are three signs, or a fourth part of a circle from each other; △ Trine, when they are four signs, or a third part of a circle from each other; ☍ Opposition, when they are six signs, or half a circle from each other.

25. The conjunction and opposition (particularly of the moon) are called the *Syzygies;* and the quartile aspect, the *Quadratures.*

26. The motion of a planet is called *direct* when it appears to go forward in the zodiac; *stationary,* when it appears for some time in the same point of the heavens; and *retrograde,* when it apparently goes backward.

27. A *Digit* is the twelfth part of the sun's or moon's diameter.

28. *Disc,* the face of the sun or moon as it appears to a spectator on the earth.

29. *Geocentric* latitudes and longitudes of the planets are their latitudes and longitudes as seen from the earth. They are called *Heliocentric,* considered as viewed from the sun.

30. In the orbit of the moon, or of a planet, that point nearest the earth is called the *Perigee,* and that farthest from the earth the *Apogee.*

31. When a planet is in that point of its orbit which is nearest the sun, it is said to be in its *Perihelion,* and when most remote from the sun, it is said to be in its *Aphelion.* The line joining those two points is called the *Line of the Apsides.*

32. The *eccentricity* of the orbit of a planet is the distance between the sun and the centre of the orbit.

33. *Occultation* is the obscuration or hiding from our view any planet by the transit of another.

34. *Transit* is the passage of a planet between the earth and the sun, or another planet. The transit of the moon across the sun's disc causes an *eclipse* of the sun; and the transit of the earth between the sun and moon, causes an eclipse of the moon.

SECTION II.

PROBLEMS ON THE CELESTIAL GLOBE.

PROB. 1.

To find the position of any constellation on the globe, having the right ascension and declination of a central point of it given.

Count the right ascension (definition 5) on the equinoctial, and bring the point where the reckoning ends to the brass meridian; then count on the meridian the degrees of declination, (def. 2), and under the given degree of declination the constellation will be found.

Exercises.

1. What constellation is situated in 10° of R. A, and 50° south declination?

Ans. Phœnix.

2. What constellation is that whose R. A. is 75°, and declination 45° north?

Ans. Auriga.

3. Find the several constellations whose right ascensions and declinations are as follow:—

R. A.	DEC.	R. A.	DEC.
283	38N	308	42N
244	26S	245	22N
105	20S	340	14N
235	10N	42	30S
278	40S	310	80S
238	65S	159	50S
185	26N	285	35S
111	32N	46	49N

Prob. 2.

A constellation given, to find the right ascension and declination of any assigned point of it.

Bring the assigned point to the meridian, and count the degrees of the equinoctial between it and the point Aries—those degrees are the right ascension; and the degree of the brass meridian which stands over the given point is the declination.

Exercises.

1. What is the right ascension and declination of the middle of Draco?

Ans. R. A. 270° Dec. 66 N.

2. Required the right ascension and declination of the right knee of Auriga?

Ans. R. A. 89° and Dec. 32° N.

3. Find the right ascension and declination of the following points:—

The right hand of Böotes,
The middle of Cor Caroli,
The eye of Ursa Major,
The eye of Taurus,
The head of Columba,
The nose of Canis Major,
The point of the tail of Draco,
The heel of Orion,
The beak of Corvus,
The centre of Horologium.

4. Find also the right ascensions and declinations of the following stars:—

		R. A.	DEC.
γ, in Ursa Major.	*Ans.*	176°	54° 30′
δ, in Leo,			
α, Regulus, in Leo,			

β, Pollux, in Gemini,
β, in Celtus,
α, Altair, in Aquila,
Algenib, in Perseus,
Autares, in Scorpio,
Rigel, in Orion,
Spica, in Virgo.

5. Find also the sun's right ascension and declination, for May 20th, June 5th, October 10th, April 16th, and December 24th.

PROB. 3.

To find a star, or other heavenly body, the right ascension and declination given.

Proceed according to the first problem; and find the stars answering to the right ascensions and declinations following, respectively.

Exercises.

1. Right ascension 75° 43′ Dec. 45° 47′ N.
Ans. Capella.
2. Right ascension 205° Dec. 50° 15′ N.
Ans. Benetnach.

3. Rt. As.	221°	27′	Dec.	27°	51′N
	212			20	0 S
	198	50		10¼	0 S
	342	0		30	36 S
	308	45		44	37 N
	231	41		27	21 N
	149	36		12	52 N
	244	29		26	0 S
	99	13		16	28 S
	110	39		32	17 N
	86	16		7	21 N

78	46	6	10 N
54	0	23	28 N
13	38	88	19 N

4. The right ascension of the lower pointer is 162° 39′, and its declination 57° 23′ N.; and the R. A. of the upper pointer is 163° 9′, and its decl. 62° 45′ N.; find them on the globe.

5. The right ascension of the pole star is 15° 45′, and its declination 88° 28′; find its position on the globe.

Remarks.

1. The fixed stars, though unchanging in their positions with respect to each other, have yet a slight annual variation in their declinations and right ascensions, for which reason, except on globes of recent construction, they will be found to vary a little from the right ascensions and declinations assigned them in the astronomical calculations of the present time.

2. The pointers are two stars in the constellation of Ursa Major, and are so called because a line joining their centres would point very nearly to the pole star, situated in Ursa Minor.

Questions.

1. What is meant by the right ascension of a star? (Def. 5.)

2. What is meant by the declination of a star? (Def. 2.)

3. What is the greatest declination a fixed star can have?

4. What is the greatest right ascension a fixed star can have?

Prob. 4.

Given the sun's right ascension, to find his declination and the day.

Count the given degrees of right ascension from Aries, on the equinoctial, bring the point where the reckoning ends to the brass meridian; the degree of the ecliptic cut by the meridian will be the sun's place, which, found on the horizon, will shew the day: that degree of the meridian which stands exactly over the *ecliptic* is the sun's declination.

Exercises.

1. Given the sun's right ascension 90°, required his declination and the day.

Ans. Dec. 23½° N., and the day June 21st.

2. Sun's right ascension 305°, required his declination, and the time.

Ans. Dec. 19° 52′ S. Day 22nd of January.

3. Find the declination and time according to each of the following—

Right Ascensions.	
48°	26°
124	64
75	200
0	87
246	360

Remarks.

1. If the day be given, the right ascension and declination may be found.

2. If the declination be given, stating whether it is northward or southward, the right ascension and time may be found.

Exercises on the Remarks.

1. What is the sun's right ascension and declination on the 21st of June?

2. Required the sun's right ascension and declination on the 22nd of January?

3. On the 15th of May what is the sun's right ascension and declination?

4. When the sun's declination is $23\frac{1}{2}^{\circ}$ N. what is the right ascension and day?

5. On what day is the sun's declination 5° S. and what is his right ascension at that time?

6. On a certain day the sun's right ascension exactly equals his declination, what is the day?

PROB. 5.

To find the latitude and longitude of a star.

If the star be on the north side of the ecliptic, elevate the north pole, or if south of the ecliptic, the south pole $66\frac{1}{2}^{\circ}$; bring the upper pole of the ecliptic to the brass meridian, and screw the quadrant exactly over it; keep the globe steady, and move the quadrant till its graduated edge comes to the star, then the degree of the quadrant cut by the star is its latitude, and the sign and degree on the ecliptic cut by the quadrant is the star's longitude.

Exercises.

1. Required the latitude and longitude of Capella, in Auriga?

Ans. Latitude 23° N., longitude 2 signs 18° $30'$ or 18° $30'$ in Gemini.

2. Required the latitude and longitude of Arided, in Cygnus?

Ans. Latitude 59° 30′ N., longitude 11 signs 4° or 4° in Pisces.

3. Find the latitudes and longitudes of the following:—

α, Altair, in the Eagle.	α, Markab, in Pegasus.
β, Pollux, in Gemini.	γ, in Ursa Major.
γ, Rastaben, in Draco.	

Prob. 6.

Given the latitude and longitude of a star or planet, to find its place on the globe.

Rectify the globe as in the preceding problem, then turn the quadrant till it cuts the given longitude in the ecliptic; under the given latitude on the quadrant you will find the star or place of the planet.

Exercises.

1. Required the star whose longitude is 11 signs 25° and latitude 35° N.

Ans. η in Pegasus.

2. What star has long. 29° in Aries, and latitude 25° 30′ N.?

Ans. β, Mirach in Andromeda.

3. What stars have the following latitudes and longitudes?

Longitude	2	6°	50	Lat.	5°	29	S.
	2	18	57		22	52	N.
	2	25	51		16	3	S.
	7	9	22		44	20	N.

Questions.

1. What is meant by the latitude of a fixed star?
2. What is meant by the longitude of a star?

3. From what circle is the latitude of a star reckoned ?

4. From what circle is the declination of a star counted ?

5. On what circles are the right ascension and longitude of a star reckoned ?

Prob. 7.

To find the sun's oblique ascension and descension for any given day, in any latitude.

Rectify the globe for the given latitude, find the sun's place for the day, bring the sun's place to the eastern edge of the horizon, and the degree of the equinoctial there cut by the horizon is the sun's oblique ascension ; turn the sun's place to the western side of the horizon, and the degree of the equinoctial which the horizon there cuts, is the sun's oblique descension.

Exercises.

1. Required the sun's oblique ascension and oblique descension at Dublin on the 23rd of November ?

Ans. The oblique ascension is 332°, the oblique descension 272°.

2. Find the sun's oblique ascension and oblique descension at the following places, according to the given days ?

At Berlin,	52°	30′	N. on the	1st of June ?
At Geneva,	46	12	N.	23d of Sept ?
At Rome,	41	53	N.	18th of May ?
At Dresden,	51		N.	4th of August ?
At C. Horn,	55	58	S.	22nd of April ?

Prob. 8

The latitude of a place and the time being given, to find what stars are then rising, setting, culminating, &c.

Rectify for the latitude of the place, bring the sun's place for the given time to the meridian, and also one of the 12's of the hour circle; then turn the globe on its axis till the given hour comes to the meridian, (observing to turn the globe eastward if the time be before noon, but westward, if after noon) then the stars along the eastern edge of the horizon are those rising at the time, those along the western side are setting, and those under the brass meridian are culminating; those stars above the horizon, if it be night at the given place, will be visible, and those below the horizon invisible.

Exercises.

1. What stars may be seen rising, culminating, and setting at the observatory of Dublin, in latitude 53° 23′ when it is 10 o'clock in the evening at that place, on the 23d of September?

Ans. Rising—The head of Pollux, the feet of Castor, the club of Orion, ζ, in Cetus, &c.

Culminating—λ, in Piscis Australis, Aquarius, head and feet of Pegasus, Cephelus, &c.

Setting—Arcturus, Böotes Serpentarius, head of Sagittarius, &c.

2. On the 4th of September, at 8 o'clock in the evening at Bermudas I. what stars are rising, culminating, and setting?

3. Find the stars rising, &c., at the following places, according to the times specified?

At Batavia, 9 o'clock P.M. October 22nd.?

At Berlin, 10 o'clock P.M. December 16th.?
At Cairo, 2 o'clock P.M. March 25th?
At Madras, 12 noon on July 24th?

PROB. 9.

To find at what hour any known star passes the meridian, on any given day.

Bring the sun's place, and one of the 12's of the hour circle to the meridian, then turn the globe till the star comes to the meridian, and the time will be seen at the edge of the meridian, on the hour circle.

Exercises.

1. What time does Lyra come to the meridian on the 15th of August?

Ans. At 8h. 45m. or 45 minutes past 8 in the evening.

2. At what hour on the 30th of March will Betelgeux come to the meridian?

Ans. 5 minutes after 5, evening.

3. Find the times at which the following stars, respectively, will be at the meridian on the 5th of December?

Cor Caroli,	Deneb, in Leo,
β, in Lepus,	Menkar, in Cetus,
γ, in Cygnus,	ζ, in Centaurus,
α, in Canis Minor,	α, in Grus.

PROB. 10.

To find on what day a given star will come to the meridian at a given hour.

Bring the star and the given hour on the hour circle to the meridian; then, if the given hour be in

the forenoon, turn the globe westward, if in the afternoon, eastward, until 12 comes to the meridian; and the degree of the ecliptic cut by the meridian is the sun's place for the day, and may be found on the horizon.

Exercises.

1. On what day will Arcturus come to the meridian at 3 o'clock in the morning?

Ans. On the 5th of March.

2. On what day will the same star be on the meridian at 8 o'clock in the evening?

Ans. On the 22nd of June.

3. Find the several days that the following stars will be on the meridian at the given times?

Sirius, at 8 o'clock evening.
α, Deneb, in Cygnus, 5 in the morning.
β, Pollux, in Gemini, 4 in the evening.
α, Vega, in Lyra, midnight.
α, Altair, in the Eagle, noon.

PROB. 11.

Given the latitude and time, to place the globe in such a position as to represent the face of the heavens at that time.

Rectify the globe for the latitude and sun's place for the day, and set the brass meridian due north and south by the compass, taking care to allow for the variation. Turn the globe on its axis till the given hour comes to the meridian, then the upper hemisphere will represent the face of the heavens at that time.

Exercises.

1. Place the globe so as to represent the face of

the heavens at Dublin on the 10th of November at 8 o'clock in the evening.

The position of the constellations at the given time will be,

On the meridian—Pegasus, Cephelus, &c.

To the east of the meridian—Cassiopeia, Andromeda, Cetus, &c.

Rising—Betelgeux; Castor and Pollux just risen.

Setting—Canes Venatici, Bŏotes, and Serpens, &c.

2. Represent the face of the heavens at London on the 9th of February at 9 o'clock in the evening.

And it will be found that Sirius is on the meridian; Procyon towards the east; and still more eastward Castor and Pollux; Regulus is exactly in the east; Arcturus has just risen; and in the N.E. are the stars in the tail of Ursa Major. In the west are Orion and Auriga, and still more westerly is Taurus, &c.

Remarks.

1. This problem furnishes a simple and ready means of becoming acquainted with the relative situations of the constellations, their names, and the most remarkable of the stars. When the globe is rectified as directed in the problem, and placed in a position from which the stars may be conveniently viewed, if the end of a pencil be placed on any constellation, so as to form the continuation of a diameter of the globe, the other end of the pencil, or pointer, will point directly to the same constellation in the heavens; by which means the constellation and all its principal stars may be observed.

2. The stars are divided into different classes ac-

cording to their apparent magnitudes; those which appear brightest are called stars of the first magnitude, the next in splendour, stars of the second magnitude, &c.; those which are the least that can be discerned without a telescope, are of the sixth magnitude; those which can be seen only with a telescope, are called telescopic stars, and have magnitudes of the 7th, 8th, &c., order.

Prob. 12.

To find those stars which never set and those which never rise in any given latitude.

Elevate the pole to the given latitude; then turning the globe round on its axis, those stars which do not descend below the horizon are they which never set; and those which do not come above the horizon are they which never rise in the given latitude.

Exercises.

1. What constellations never set at Madrid, lat. 40° 25′ N.?

Ans. Cephelus, Draco, Ursa Minor, the head, body, and tail of Ursa Major, the head of the Lynx, the head of Auriga, Camelopardalus, and Cassiopeia, &c.

2. What constellations never rise at Cape St. Vincent, lat. 37° N.?

Ans. Toucana, Hydrus, Horologium, Reticulus, Dorado, Piscis Volans, part of Argo Navis, Cameleon, Crux, Musca Australis, Triangulum, Apus, Pavo, &c.

3. What stars never rise at Bagdad, lat. 33° 19′ N.?

4. What stars cannot be seen from the observatory of Edinburgh, lat. 55° 57′ N.?

Remarks.

1. Those stars which do not set at a place are called stars of perpetual apparition; those which do not rise are called stars of perpetual occultation.

2. The circles of perpetual apparition and occultation are circles described parallel to the equinoctial, at a distance from it equal to the complement of the latitude of the place; that is, at a distance equal to what the latitude wants of 90°.

PROB. 13.

To find the time of the rising, culminating, or setting of a given star at any place on a proposed day.

Rectify the globe for the latitude and sun's place, turn the star to the eastern edge of the horizon, and the hour at the meridian is the time of its rising; bring it to the meridian, and the hour that is at the meridian with it is the time that it culminates; in the same way by turning it to the western side of the horizon, the hour will be found at which it sets.

Exercises.

1. At what hour does Deneb, in the tail of Leo, rise, culminate, and set at London on the 20th of October?

Ans. Rises at half-past 2 A M.
Culminates 55 min. after 9, A.M.
Sets 45 min. after 5, P.M.

2. At what hour does Arcturus rise, set, and culminate at Petersburgh on the 15th of February?

3. Required the hour at which Altair, in the Eagle rises, Procyon, in Canis Minor, culminates, and the Hyades, in Taurus, set at Alexandria, on the 21st of October?

4. What stars are setting to London when Deneb is on the meridian on the 29th of June, and what is the hour of their setting?

Prob. 14.

To find the oblique ascension and descension of a given star.

Elevate the pole to the latitude of the place, bring the given star to the eastern edge the horizon, and the degree of the equinoctial cut by the horizon, is the oblique ascension.

Turn the star to the western side of the horizon, and the degree of the equinoctial cut by the horizon, is the oblique descension.

Exercises.

1. Required the oblique ascension and oblique descension of Scheat, in Pegasus, at Amsterdam, lat 52° 22′ N.?

Ans. Oblique ascension 302 degrees.
Oblique descension 26 degrees.

2. Required the oblique ascension and descension of Aldebaran, at Delhi, lat. 28° 37′ N.?

3. Required the oblique ascension and descension of the following stars at the given places?

Vega, in the Harp, at lat. 24° N.
Spica Virginis, at lat. 45° S.
Castor, at Pekin, lat. 39° 54′ N.

Prob. 15.

To find the amplitude of any star, and also its diurnal arc for any given day, in a given latitude.

Having elevated the pole, as in the foregoing problem, bring the star to the eastern edge of the

horizon, and its distance from the east point of the horizon is its rising amplitude. Set 12 on the hour circle to the meridian, and turn the globe westward till the star comes to the western edge of the horizon, the hours passed over on the hour circle will be the diurnal arc, or the time the star continues above the horizon in the given latitude; and the distance of the star from the west point of the horizon its setting amplitude.

Exercises.

1. Required the amplitude and diurnal arc of Betelgeux, in Orion, at Malta, lat. 35^0 53′ N.

Ans. $9\frac{1}{2}^0$ N. of the E. and N. of the W.
Diurnal arc 12 hours, 44 minutes.

2. Find the amplitudes and diurnal arc of γ, Rastaben in Draco, at the equator on the 1st of July.

3. What is the difference in time between the diurnal arc of β, Rigel, in Orion, and that of β, Albireo, in Cygnus, at Mocha, lat. 13^0 20′ N. on the 15th of November?

Prob. 16.

Given the latitude and time to find the azimuth and altitude of a given star.

Rectify the globe for the latitude and sun's place, screw the quadrant in the zenith, and having turned the globe till the given hour comes to the meridian, keep it steady, and move the quadrant to the given star; the degree of the quadrant then over the star is its altitude; and the degree of the horizon cut by the quadrant is the azimuth, and may be reckoned either from the north or south point of the horizon.

Exercises.

1. Required the altitude and azimuth of each of the following stars, on the 16th of March, at half-past 5 o'clock in the morning, at the observatory of Marseilles, in lat. 43° 18′ N.; viz., Algenib, in Pegasus; Almaach, in Andromeda; Arided, in Cygnus; and Vega, in Lyra?

Ans.	Algenib,	alt. 2°	azim. 72° 30′	from N.
	Almaach,	6 30′	36	from N.
	Arided,	56	69	from N.
	Vega,	76 30	79	from S.

2. Required the altitude and azimuth of the pointers, and of Mirach, in Andromeda, at 7 o'clock in the evening, on the 10th of December, at Dublin?

Prob. 17.

Given the altitude of a star, at any place, and the day of the month, to find the hour.

Note—Should the given altitude be less than the meridian altitude, there may be two different hours found, at one of which the star is on the eastern side of the meridian; and at the other on the western side.

Rectify the globe for the latitude and sun's place; screw on the quadrant, and cause it to cut the star in the given degree of altitude, the hour at the meridian is the time sought.

Exercises.

1. At Cape Finisterre, in lat. 42° 54′ N., on the 20th of April, Procyon was observed to have an altitude of 31°, required the hour?

Ans. Seven minutes after 2 P. M. or two minutes

after 9 P. M.; for at each of these times it has the altitude given.

2. What is the hour at Bangalore, lat. 12° 57′ N., on the 10th of February, when α, in Columba has an altitude of 42° 33′?

Ans. 8 o'clock in the evening.

3. Required the hours when the Pleiades, in Taurus will have an altitude of 40° at the I. of St. Helena, lat. 15° 55′ S., on the 1st of December?

4. Find the hours at which Arcturus, in Bōotes; Altair, in Aquila; Vega in Lyra, and Markab, in Pegasus will each have an altitude of 20°, on the 1st of March, at London, lat. 51 30′?

Questions on some of the foregoing Problems.

1. What is meant by the oblique ascension and descension of the sun or a star, (definition 6, and p. 7.)?

2. What do you learn in the 11th problem?

3. Can you describe the method there given of finding the relative positions of the stars, and of their names?

4. Into what classes are the stars divided?

5. What are those stars called which cannot be seen without a telescope? (p. 12.)

6. Are magnitudes assigned to those? what magnitudes?

7. What term is applied to those stars which never rise in a given latitude?

8. What are those called which never set in a given latitude?

9. How far do the circles of perpetual apparition and occultation for any latitude lie from the equator?

10. What do you mean by a star's culminating (p. 13, and definition 12)?

11. What is meant by the amplitude of a star?

12. What is meant by the diurnal arc of a star? (p. 15.)

13. What is the azimuth of a star or planet? (p. 16.)

14. What do you mean by the altitude of a star or planet? (prob. 16.)

Prob. 18.

The meridian altitude of a given star being known, it is required to find the latitude.

Bring the star to the brass meridian and count on the meridian from the star, southwards, the given degrees of altitude; bring the point where the reckoning ends to the south point of the horizon, the elevation of the north pole will then be the required latitude north. It is easy to apply the problem to the southern latitudes if necessary.

Exercises.

1. In the northern hemisphere the meridian altitude of Arcturus was observed to be 40°, required the latitude?

Ans. 69° N.

2. In what degree of north latitude is the meridian altitude of β, in Grus 12°?

Ans. 29° 30′ N.

8. In what degree north lat. is the meridian altitude of Rigel, in Orion 43°?

4. In what latitude north, is the meridian altitude of Castor 18°?

Prob. 19.

Two stars being given, one on the meridian, and the other on the east or west part of the horizen, to find the latitude of the place.

Bring the star observed to be on the meridian to the brass meridian, keep the globe steady, and elevate or depress the pole till the other star comes to the east or west side of the horizon; the degree at the horizon under the elevated pole will be the required latitude.

Exercises.

1. When Arcturus was rising, Castor was touching the meridian—required the latitude?
Ans. 25^0 N.
2. β, in Libra was on the meridian when Capella was setting; what was the latitude?
Ans. 40^0 N.
3. Lyra was on the meridian when Antares was setting—required the latitude?
4. When Aldebaran was rising, Arided, in Cygnus was observed on the meridian, what was the latitude?

Prob. 20.

Given the time when any known star rises or sets, to find the latitude.

Bring the sun's place for the given day to the meridian, and also one of the 12's on the hour circle; then turn the globe till as many hours have passed the meridian as the given time is from noon; (observing to turn it eastward for the forenoon hours, but for the afternoon westward;) elevate or depress

the pole till the given star comes to the horizon, and the elevation of the pole will show the latitude.

Exercises.

1. In what latitude does Almaach, in Andromeda rise at a quarter past 7, on the 15th of January?

Ans. Lat. 45° N.

2. In what latitude does Vendematrix, in Virgo set at a quarter before 2 o'clock in the afternoon, on Christmas day?

Ans. Lat. 54½ N.

3. In what latitude does Betelgeux rise at 7 o'clock in the evening, on the 1st of January?

4. In what latitude does β, in Capricornus rise at 10 o'clock in the morning, on the 24th of November?

Prob. 21.

From an observation of two stars, rising together, or two stars setting together to determine the latitude.

If the two stars were observed rising, bring them towards the eastern side of the horizon; if setting, turn them towards the western side; then elevate or depress the pole till the two stars coincide with the horizon; the elevation of the pole will show the latitude.

Exercises.

1. In a certain latitude north, Arcturus and Cor Caroli were observed to set at the same time—required the latitude.

Ans. 32° 45′ N.

2. In north latitude Pollux and Betelgeux were observed rising at the same instant, what was the latitude?

Ans. 46° 30′ N.

3. In north latitude, Vega, in Lyra, and Ras Alhhagus, in Hercules were observed to rise at the same moment—required the latitude?

Ans. 24° 40′ N.

Prob. 22.

Given the latitude, the sun's place, and two stars having the same azimuth, to find the hour of the night.

Rectify for the latitude, zenith, and sun's place; turn the globe and quadrant till the two given stars coincide with the quadrant's graduated edge; the hour at the meridian will be the hour of the night; and the degree of the horizon cut by the quadrant will be the common azimuth of the given stars.

Exercises.

1. On the 10th of January, two stars, β, in Aquarius and β, Scheat, in Pegasus, were observed from the latitude of London, to have the same azimuth at a certain hour, required the time?

Ans. 4 min. after 6 in the evening, and their common azimuth was 63° 30′ from the S. towards the west.

2. In the latitude of Madrid, 40° 25′ N., the two stars in the tail of Leo were observed to have the same azimuth; the sun's place being 1° in Scorpio, required the day, the exact hour, and the common azimuth.

Ans. 24th of October, at half past four in the morning; the common azimuth 84° 30′ from N. to E.

PROB. 23.

The latitude, sun's place, and two stars having the same altitude given to find the hour.

Rectify, as in the foregoing problem; then turn the globe till the same degree of the quadrant cuts both stars; the hour at the meridian is the time sought.

Exercises.

1. When in latitude 56° 30′ N. on the 30th of April, the two stars, Almaach, in Andromeda, and Betelgeux, in Orion have equal altitudes, what is the hour?

Ans. Half past seven in the evening.

2. When on the 11th of May in lat. 49 N. Markab, in Pegasus, and the bright star in the head of Andromeda have both the same altitude, what is the hour?

PROB. 24.

Given the latitude, day of the month, and the azimuth of a known star, to find the hour of the night, and the altitude of the star.

Rectify for the given latitude, for the zenith and sun's place; cause the quadrant to cut the given degree of azimuth on the horizon; the quadrant still remaining at the azimuth, turn the globe till the star comes to its edge: the hour then at the meridian will be the time sought; and the height of the star above the horizon, reckoned on the quadrant will be the altitude of the star.

Exercises.

1. At Astracan, lat. 46 21′ N., the azimuth of

Cor Caroli was 31° from N. towards W. on the 10th of November; required the hour, and the altitude of the star.

Ans. Hour, half past seven P. M. alt. 4° 30′.

2. At Alexandria, lat. 31° 13′ N. on December 16th, Arcturus had an azimuth of 82° 30′ from the north towards the east; what was the altitude and the hour?

Ans. Altitude, 29° ; hour, 4 in the morning.

PROB. 25.

Given the latitude, the hour, and the azimuth of a known star, to find the altitude of the star, and the day of the month.

Rectify the globe for the latitude and for the zenith, and bring the quadrant to the given azimuth; turn the globe till the star comes to the edge of the quadrant; the distance of the star above the horizon, reckoned on the quadrant is the required altitude. While the star and quadrant are in this position, set one of the 12's to the meridian; then turn the globe on its axis till as many hours have passed the meridian as the given hour is from noon, observing to turn the globe westward if the given time be before noon, but eastward if afternoon; when this is done the degree of the ecliptic cut by the meridian will show the day on the horizon.

Exercises.

1. At Paris, lat. 48° 50′ at 3 o'clock in the morning, the azimuth of γ in Lyra was 58° 30′ from the north towards the east; required the altitude of the star, and the day of the month?

Ans. Altitude, 27°; day, 4th of March.

2. At Dublin, at 9 o'clock in the evening, the azimuth of Regulus was 70° from the south to the west; what was the altitude of the star, and the day of the month.

Ans. 30° ; 6th of July.

3. In the latitude of 60° N. Alcor, in the tail of Ursa Major, was observed at half past ten o'clock at night on an azimuth of 39½ degrees from the south towards the west; required the altitude of the star, and the day of the month?

Ans. Alt. 34° ; day, 24th of August.

PROB. 26.

Given the latitude to find the meridian altitude of any given star.

Rectify for the latitude; bring the given star to the meridian, and count the degrees between the star and the horizon; those degrees are its meridian altitude.

Exercises.

1. What is the meridian altitude of Procyon, in Canis Minor, at the Cape of Good Hope, lat. 34° 30′ S.?

Ans. 50°.

2. Find the meridian altitude of Deneb, in the tail of Ursa Major, at Dublin.

3. What is the meridian altitude of Sirius, in Canis Major, at the equator?

PROB. 27.

Given the day on which a certain star comes to the meridian, to find the hour; or to find the hour on

any night, by observation of a star upon the meridian.

Rectify the globe for the sun's place for the day; then bring the star to the meridian, and the hour at the meridian on the hour circle will shew the time.

Exercises.

1. At what hour, on the 25th of May, does Vindematrix, in Virgo, come to the meridian?

Ans. Forty min. after 8 in the evening.

2. At what hour, on the 8th of December, does Capella come to the meridian?

Ans. 12 o'clock at night.

3. On the 15th of March, at what hour does Regulus come to the meridian?

4. Find the time on the 4th of September, that γ, in Cygnus, comes to the meridian?

5. What is the time after sun-set that ϵ, Enir, in Pegasus, comes to the meridian, on the 1st of December.

PROB. 28.

Given the latitude, the month, day, and hour of the day, together with the altitude and azimuth of a star, to find the name of the star.

Elevate the pole to the given latitude, screw the quadrant in the zenith, and bring the sun's place and one of the 12's of the hour circle to the meridian; then turn the globe on its axis, until as many hours have passed the meridian as the given time is from noon; observing to turn it eastward if the given hour be in the forenoon, but if in the afternoon, westward; keep the globe steady, and turn the quadrant to the given azimuth on

the horizon; the star will then be found under the given degree of altitude on the quadrant.

Exercises.

1. At Lisbon, lat. 38° 42′ N. a star was observed, on the 7th of October, on an azimuth of 35° from the north towards the east, and at an altitude of 40° ; required the name of the star, the hour being 5 o'clock in the morning?

Ans. Dubhe, one of the pointers.

2. At Port Royal, in Jamaica, lat. 17° 58′, on the 23rd of January at 11 o'clock at night, a star was noticed in alt. 53° , and azimuth 89½° from the south towards the east; required the name of the star?

Ans. Regulus, in Leo Major.

3. At London, on the 21st of December, at 4 o'clock in the morning, the altitude of a star was 50°, and its azimuth was 37° from the south towards the east; required the name of the star?

Ans. Deneb, in the tail of Ursa Major.

4. The altitude of a star was 26°, its azimuth 76½ degrees from the south, towards the west, at 11 o'clock at night, in the lat. of London, on the 11th of May. What star was it?

Ans. Regulus.

5. In the latitude of London, on the 5th of September, at 2 o'clock in the morning, a star had 34 degrees of altitude, and 57 degrees of azimuth, from the north towards the east. Required the name of the star?

PROB. 29.

Given the place and time, to find the depression of

the sun below the horizon, and his azimuth, at any hour of the night.

Rectify the globe for the latitude, zenith, and sun's place for the given day, and adjust it to the given hour of the night; keeping the globe steady, look for the point of the ecliptic, which is directly opposite that of the sun's place; turn the quadrant to it, and note its altitude and azimuth; this altitude will be the required depression; the azimuth will also be that which is sought, if considered as in the opposite quarter of the compass.

Exercises.

1. At Havannah, lat. 23° 9′ N., what is the sun's depression and azimuth, at 9 o'clock at night, on the 10th of January?

Ans. Depression 48°; azimuth 83° N.W.

2. At Cork, lat. 51° 52′ N., what is the sun's depression and azimuth, at 11 o'clock at night, on the 26th of June?

Ans. Depression 13°; azimuth 15° N.W.

3. At Cape Matapan, 36° 23′ N. lat., required the sun's depression below the horizon, and his azimuth, at 7 o'clock in the evening, on the 1st of December?

4. At the straits of Magellan, lat. 53° 8′ S. what is the sun's depression and azimuth, at 10 o'clock at night, on the 7th of April?

Prob. 30.

To find those risings and settings of the stars noticed by ancient poets, and thence called the poetical rising, &c. (see Definition 10.)

Given the latitude to find the time of the year at which a given star rises or sets cosmically.

Rectify for the given latitude; bring the star to the eastern edge of the horizon; the point of the ecliptic that rises with it will show the day on the horizon. Turn the star to the western side of the horizon, and again observe what point of the ecliptic is at the eastern side, that point of the ecliptic will show on the horizon the day on which the star sets cosmically.

Exercises.

1. At what time of the year does Marsic, in the arm of Hercules, rise cosmically; and on what day does it set cosmically at New Orleans, lat. 30° N.

Ans. Rises cosmically 2nd of November.
Sets cosmically 15th of June.

2. At Damietta, lat. 30° 25 N. required the day on which Capella rises cosmically, and also the day on which it sets cosmically?

Ans. Rises cos. 12th of May.
Sets cos. 29th of December.

3. On what day does Castor rise cosmically, and on what day does Regulus set cosmically at London?

Prob. 31.

Given the latitude, to find the time of the year at which a given star rises or sets acronically.

Rectify for the latitude, and bring the star to the eastern edge of the horizon; the degree of the ecliptic then at the western edge of the horizon will show the day on which the star rises acronically. Turn the star to the western side of the horizon, note the point of the ecliptic that sets with it, for that point of the ecliptic found on the horizon will show the day on which the star sets acronically.

Exercises.

1. Required the day of the year on which Arcturus rises acronically at Petersburg, lat. 59° 56′ N.; and also the day on which it sets acronically at the same place.

Ans. Rises acron. 16th of March.
Sets acron. 12th of January.

2. On what day of the year does Procyon in Canis Minor, rise acronically at Hanover, lat. 52° 22′ N., and on what day does it set acronically?

Ans. Rises acron. January 29th.
Sets acron. June 17th.

3. Find the time of the year that Sirius, Pollux, and Altair, severally rise and set acronically, at London.

PROB. 32.

To find the time of the year when a given star rises or sets heliacally.

The time will vary according to the magnitude of the given star; for the brighter a star is, the sooner will it shine forth after the sun has set. Stars of the *first* magnitude may be seen rising or setting, when the sun is twelve degrees below the horizon; stars of the *second* magnitude do not appear until the sun has descended thirteen degrees; those of the *third* magnitude do not become visible until he has descended fourteen degrees below the horizon; and so on, adding a degree for each magnitude; so that, having the latitude given, proceed thus—

Elevate the pole for the latitude; screw the quadrant in the zenith; bring the given star to the eastern edge of the horizon, and keeping it steadily there, move the quadrant, till it cuts the ecliptic at

the eastern side, twelve degrees below the horizon, for a star of the first magnitude; thirteen degrees, for a star of the second magnitude, &c.; the degree of the ecliptic thus cut by the quadrant, will, if found on the horizon, show the day on which the star rises heliacally. For the setting, proceed in the same manner, bringing both star and quadrant to the western side of the horizon; and the degree of the ecliptic cut by the quadrant will show on the horizon the day on which the star sets heliacally.

Exercises.

1. At what time of the year does Betelgeux rise heliacally, in the latitude of London?

Ans. 27th of July.

2. At what time of the year does the star of the second magnitude, in the Lion's tail, set heliacally, in the latitude of Dublin?

Ans. 10th of September.

3. In the latitude of Leipsic, 51° 20′ N., at what time of the year does Arcturus rise heliacally?

4. At Barbadoes I., 13° 5′ N., at what time of the year does α, Canopus, in Argo Navis, set heliacally?

Prob. 33.

The latitude of a place, and the day of the month given, to find all those stars that rise and set cosmically, acronically, and heliacally.

For the cosmical rising and setting—

Rectify for the latitude; bring the sun's place to the eastern edge of the horizon, and all the stars then along that edge rise cosmically, and those along the western edge set cosmically.

For the acronical rising, &c.

Having rectified as before, bring the sun's place for the day to the western edge of the horizon, then the stars which come to the western edge along with it, set acronically; and those along the eastern edge rise acronically.

For the heliacal rising, &c.

Rectify for both latitude and zenith; turn the sun's place and quadrant to the eastern side, and cause the 12th degree of the quadrant to cut the sun's place below the horizon; then all the stars of the first magnitude along the eastern edge of the horizon are those which rise heliacally on the given day; proceed in the same manner for the other magnitudes, causing the sun's place to meet the 13th, 14th, &c. &c. degree of the quadrant, and so bringing the stars of the 2nd, 3rd, &c. magnitude to the eastern side of the horizon. By turning the sun's place and quadrant westward, the stars that set heliacally may be found in a similar way.

Exercises.

1. In the lat. of Holyhead, 53° 18′ N., required the names of the stars that rise and set cosmically on the 7th of December.

Ans. Antares, in the Scorpion, the Cluster, in Delphinus, or the Dolphin, ζ, in Serpentarius, and η, in Pegasus rise cosmically.

The two stars in the foot of Perseus are the only ones of importance that are setting cosmically at the time.

2. Find what stars rise and set acronically at Cape Clear, lat 51° 25′, on the 5th of July.

3. What stars rise, and what stars set heliacally, of any magnitude, at Dantzic, lat. 54° 20′ N., on the 31st of January?

Questions on some of the foregoing Problems.

1. What is meant by the meridian altitude of a star?
2. How would you find the sun's meridian altitude according to problem 26?

Ans. By bringing the sun's place to the meridian, as is done with a star.

3. What is meant by a star's passing the meridian?
4. What do you mean by the depression of the sun below the horizon? (prob. 29.)
5. How do you know that the proper depression is found by taking the altitude of the opposite point of the ecliptic?
6. Why is the azimuth to be considered as on the opposite quarter of the compass?
7. What are the poetical risings and settings of the stars? (prob. 30.)
8. Why are they called poetical?
9. What is the cosmical rising and setting?
10. What is the acronical rising and setting?
11. What is the heliacal rising and setting?

PROB. 34.

Given a place and the month and day, to find the time that a given star will rise or set.

Rectify the globe for the latitude and sun's place for the given day; turn the star to the eastern side of the horizon, then the hour at the meridian will be the time of its rising; turn it to the western side, and the hour at the meridian will show the time of its setting.

As it passes the meridian the time of its culminating may be noticed if required.

Exercises.

1. In the lat. of Drontheim, 63° 25′ N., what is the time that Arcturus rises, and what time does he set, on the 30th of May?

Ans. Rises half-past 12, A.M.
Sets at a quarter to 7 P.M.

2. At Cape Clear, lat. 51° 25′ N., required the time of the rising and culminating of Arietis, in Aries, on the 12th of February?

Ans. Rises 2 minutes after 8, A.M.
Culminates 9 minutes after 4, P.M.

3. Required the time at which β, Pollux, in Gemini rises and sets, on February 2nd, at Geneva, lat. 46° 12′ N.?

4. At what time on the 6th of September, does δ, in Orion rise, and culminate, at Cape Finisterre, lat. 42° 56′ N.?

PROB. 35.

Given the latitude of a place, the day of the month, and the altitude of a star, to find the hour of the night, and the star's azimuth.

Rectify the globe for the latitude, zenith and sun's place; bring the quadrant to that side of the meridian on which the star was, when observed; turn the globe westward, till the centre of the star cuts the given altitude on the quadrant; count the hours which have passed the meridian, and they will show the time from noon when the star will have the given altitude: the quadrant will cut the azimuth on the horizon.

Exercises.

1. At Jerusalem, lat. 31° 48′ N., on the 10th of January, *α*, Markab, in Pegasus was observed on the east side of the meridian, at an altitude of 9°; required the hour, and the star's azimuth?

Ans. Half-past 9 in the morning. Azimuth 78½° in the S.E. quarter.

2. At Quebec, lat. 46° 49′ N., on the 4th of March, Antares, in Scorpio, was on the western side of the meridian, its altitude at the time being 13°; required the hour, and the azimuth of the star?

Ans. Five o'clock, morning. Azimuth 23½ deg. S.W.

3. On the 5th of December, Deneb, in the tail of Ursa Major, had an altitude of 32° when on the west side of the meridian; what was then the hour at London, and what the azimuth of the star?

Prob. 36.

To find the part of the earth to which a star will be vertical at a given hour.

Rectify the celestial globe for the sun's place for noon of the given day; bring the star to the meridian, noting how many hours &c., after the sun it culminates; observe also its declination; then, taking the terrestrial globe, find the meridian on which it is noon at the given time (by prob. 15. ter. globe,) this done, turn the globe westward until the difference of time between the culmination of the sun and star, which has been just found by the celestial globe, has passed the meridian; then, under the observed point of the star's declination, the place on the terrestrial globe will be found.

Exercises.

1. Required the place to which Arcturus will be vertical on the 6th of May, when it is 10 o'clock at night at Jerusalem?

Ans. At a spot in Africa; in longitude 21°. E. latitude 20° N.

2. Required the part of the earth to which β, in Orion's heel, will be vertical, on the 21st of March, when it is 28 minutes after 9 o'clock in the morning, at London?

Ans. It will be vertical on the eastern verge of the I. of Java.

3. When it is 7 o'clock in the evening at the Cape of Good Hope on the 3rd of November, required the part of the earth to which α, Antares, in the Scorpion, will be vertical?

Prob. 37.

The altitudes of two stars given, to find the latitude of the place.

Subtract the altitude of each star from 90°; the remainders will be the zenith distances of the stars at the time; take, in a pair of compasses, (one leg of which carries a black lead pencil) the zenith distance of one of the stars, measured on the equinoctial, and placing one leg of the compass on that star, describe an arc with the pencil leg; take in the same way, from the equinoctial, the zenith distance of the other star, and taking this star as a centre, describe an arc crossing the former: the point of intersection, if brought to the brass meridian, will shew the latitude.

Exercises.

1. From a certain latitude north, the star Betelgeux was observed at an altitude of 50° at the same time that Castor had an altitude of 48° 30′; required the latitude?

Ans. 39 deg. north.

2. When Vega had an altitude of 53°, Arided was in altitude 39°, the observation was made in the northern hemisphere, required the latitude?

Ans. 54 deg. N.

The altitude of Arcturus was 63°, when that of Spica Verginis was 60° ; in what latitude north was the observation made ?

Ans. 15 deg.

Remarks.

1. Here the zenith distances are the two sides, and the distance between the centres of the two stars is the base of a triangle, which is thus given in position; and when the triangle is constructed, the vertex of it is at the zenith, and shows the latitude of the place.

2. It is plain that if the given stars have the same azimuth, the problem becomes impossible; for the arcs in that case will not intersect.

3. The zenith distance of any celestial object is the arc of a vertical circle, contained between the centre of the object and the zenith.

4. The polar distance of any celestial object is an arc of a meridian, contained between the centre of that object and the pole of the equinoctial.

PROB. 38.

Given the altitude of the sun, on any day, together with the latitude, to find the hour.

Rectify the globe for the given latitude, and also

for the zenith and sun's place for the given day; turn the sun's place and quadrant both eastward until the sun's place coincides with the given degree of altitude on the quadrant; the hour at the meridian will show the time in the forenoon at which the sun has the altitude given. By turning the sun's place and quadrant westward, another hour will be found, which will be the time that the sun will have the same altitude in the afternoon.

Exercises.

1. In the latitude of 30° north, the sun's altitude was observed to be 50° on the 15th of July, required the hour?

Ans. If the observation was made in the morning it was 9 o'clock, if in the afternoon 3 o'clock.

2. Required the hour, on the morning of the 25th of March, that the sun's altitude at Lisbon, lat. 38° 43′ N, will be 22 degrees?

3. At Cape Verd, lat. 14° 50′ north, at what hour in the afternoon on the 1st of August will the sun's altitude be 16 degrees?

PROB. 39.

Given the latitude, day of the month, and sun's azimuth, to find the hour of the day.

Rectify for the latitude, zenith, and sun's place for the given day; bring the quadrant to the given azimuth on the horizon; turn the globe till the sun's place touches the edge of the quadrant; the hour then at the meridian will be the required time.

Exercises.

1. On the 20th of April, at Petersburgh, lat.

59° 57′ N., the sun's azimuth was observed to be 70° from the south towards the east: required the hour?

Ans. 8 o'clock in the morning.

2. At Land's End, lat. 50° 4′ N., the sun's azimuth was observed, on the 5th of January, to be 14° 30′ from the S. towards the E. Required the hour?

Ans. 1 o'clock in the afternoon.

3. At Philadelphia, lat. 59° 57′ N., required the hour at which the sun's azimuth is 50 degrees from the south towards the west on the 2nd of June?

4. At Canton, lat. 23° 7′ N., it is required to find at what time on the 11th of September the sun's azimuth will be 38° from the south towards the east.

Prob. 40.

Given the latitude of a place, the day of the month, and the hour of the day, to find the Nonagesimal degree of the ecliptic, its altitude and azimuth.

Having first rectified for the latitude, zenith, and sun's place, adjust the globe to the hour given, turning it eastward for a morning hour, westward for an afternoon hour; keeping the globe steady, count 90° from either side of the horizon upwards on the ecliptic; the degree at which this reckoning ends is the nonagesimal degree. By bringing the quadrant to it, its altitude and azimuth may readily be found.

Exercises.

1. At Cork, lat. 51° 54′ N., what is the nonagesimal degree, its altitude and azimuth, at 4 o'clock in the evening on the 24th of May?

Ans. The nonagesimal degree is 23 in ♋ ; its altitude 58° 45′ ; and azim. 12° 30′ S. W.

2. At New York, lat. 40° 42′, on the 16th of February, at seven o'clock in the evening ; required the point of the ecliptic which is the nonagesimal degree, also its altitude and azimuth ?

Ans. The nonagesimal degree is 19° in Gemini ; its altitude 72°, and azim. 8½ S. E.

Remarks.

1. The nonagesimal degree of the ecliptic is the point most elevated above the horizon at a given time.

2. The medium cœli, or mid-heaven, (*see next prob.*) is that point of the ecliptic which is upon the meridian at a given time.

Prob. 41.

Given the latitude, month, and day, and hour of the day, to find the medium Cœli, or mid-heaven, its longitude, altitude, and right ascension.

Having rectified the globe, and adjusted it to the given hour, as in the foregoing problem, the degree of the ecliptic which is cut by the brass meridian is the medium cœli ; if you cause the quadrant of altitude to pass through it from the zenith, the degree of the quadrant directly over it will be its altitude ; that degree of the equinoctial which is cut by the meridian is the right ascension.

Exercises.

1. What degree of the ecliptic is in the medium cœli, or mid-heaven ; what is its longitude, altitude, and right ascension at Liverpool, lat. 53° 25′ N. on the 10th of October, at 5 o'clock in the afternoon ?

Ans. The medium cœli is 1° in ♑
Longitude, 9 signs, 1 degree.
Altitude, 13° 5′.
Right ascension, 271°

2. At Dublin, on the 16th of March, at 4 o'clock in the morning, required the longitude, altitude, and right ascension of the medium cœli?

Prob. 42.

To find the distances of the stars from each other in degrees, or to find the angle which the arc of a great circle intercepted between any two stars subtends as viewed from the earth.

Lay the graduated edge of the quadrant over any two stars, and the degrees between them counted on the quadrant will be the angular distance required.

Exercises.

1. What is the angular distance between the two stars in the Lion's tail?
Ans. 10° 30′

2. What is the angular distance between Castor and Pollux, in Gemini?
Ans. 4° 45′.

Prob. 43.

To find the ascensional difference, or the time the sun rises before or after 6 o'clock.*

Find the sun's right ascension and also his oblique ascension for the given day; subtract the less from

* The time of sun-rise or sun-set may be found much more readily by Prob. 20, Terrestrial Globe.

the greater, let the degrees in the remainder be reduced to time (see problem 14, Terrestrial Globe) this time subtracted from 6 if the sun's declination be north, or added to 6 if the declination be south, will give the time of his rising on that day.

Example.

Find by ascensional difference the hour of sun-rise on the 1st of July, at London.

The right ascension on the 1st of July is 100°, the oblique 68° ; their difference 32°, reduced to time, will give 2h. 8m. which subtracted (in this case) from 6 gives 3h. 52m., or 52 minutes after 3 for the time of sun-rise at London on that day ; which is correct to about two minutes.

From what has already been explained, it may be hoped that the learner will find no difficulty in performing the nine problems which immediately follow; they shall therefore with an occasional observation and some exercises, be left to his ingenuity.

PROB. 44.

The declination of a star given, to find what parts of the earth it passes vertically over.

Observation.

The star will pass vertically over all places whose latitude is equal to the star's declination.

Exercises.

1. Over what parts of the earth does Arcturus pass vertically?

2. Over what places does the star β in Libra, pass vertically?

3. Over what places does γ in Ursa Major pass vertically?

4. What is the common latitude of those places to which Sirius, whose declination is 16° 30′ S. passes vertically?

PROB. 45.

To find what places of the earth pass under a given star.

Observation.

This is so like the foregoing problem that the exercises given above may be used for it.

Thus:—What places of the earth pass under Arcturus, &c.?

PROB. 46.

Given the latitude of a place to find what stars it passes directly under.

Observation.

The place will pass under all those stars whose declination is equal to the given latitude.

Exercises.

1. The latitude of St. Helena I. is 15° 55′ S. under what stars does it pass?

2. The latitude of Batavia is 6° 9′ S. what stars culminate directly above it?

3. The latitude of the Lizard Point is 49° 58′ N. required the stars that come successively to its zenith?

PROB. 47.

To find what stars will be on the meridian at a given time.

(See problem 8.)

Exercises.

1. What stars are on the meridian of London at 5 o'clock in the morning on the 10th of December, and on the 5th of January?

2. What stars come to the meridian of Belfast on the 8th of June at 11 o'clock at night; and at 3 o'clock in the morning?

PROB. 48.

To find the point of the compass on which a star rises or sets in a given latitude.

Observation.

Use the star as you would the sun's place, and proceed by problem 20, Terrestrial Globe.

Exercises.

1. On what point of the compass does Rigel, in Orion, set in the lat. of 34 N.?

2. The lat. of Copenhagen is 55° 41′ N. required the point of the compass upon which Aldebaran in Taurus rises and sets in that latitude.

PROB. 49.

Given the latitude, to find the point of the ecliptic rising or setting with a given star.

Exercises.

What point of the ecliptic rises with Deneb, what point rises with Procyon, and what point with Regulus, in the latitude of London?

PROB. 50.

To find at what time of the year a given star will be upon the meridian at midnight.

Observation.

If the star be brought to one side of the meridian, the sun's place for the required time will be at the opposite side.

Exercises.

1. At what time of the year does Capella come to the meridian at midnight?

2. At what time of the year do all those stars, whose right ascension is equal to that of Betelgeux, come to the meridian at midnight?

3. Find the several days of the year when the following stars come to the meridian at midnight, viz. Arietis in Aries, Zubenich in Libra, Mirach in Bōotes, Alderamin in Cepheus, Rastaben in Draco, and Mencar in Cetus.

PROB. 51.

To find when a star comes to the meridian with the sun.

Exercises.

1. On what day does Algorab in Corvus come to the meridian with the sun?

2. On what day does Alioth in Ursa Major come to the meridian at noon?

PROB. 52.

To find the interval of time that elapses between the risings, culminatings, and settings of two given stars, the latitude being given.

Exercises.

1. What is the difference of time between the rising of Aldebaran and that of Betelgeux, required

also the difference of time in their culminating, and what time elapses between their settings in the latitude of London?

2. How much in time differs Regulus from Deneb in rising, culminating, and setting at the Cape of Good Hope, lat. 33° 56′ S.?

PROBLEMS RELATING TO THE MOON AND PLANETS.

From the nature of the motions of the moon and planets, their places cannot be laid down on the globe as is the place of the sun or of a fixed star. We must therefore have recourse to an Ephemeris or the Nautical Almanack to ascertain their positions at a given time.

In White's Ephemeris, the moon's latitude, longitude, and declination are given for every day at noon.

The right ascensions at noon, of the planets, Saturn, Jupiter, Mars, Venus and Mercury is also given, and their declinations for every sixth day of the month.

PROB. 53.

To find the portion of her orbit through which the moon passes from the noon of any day to the noon of the following day.

Take the moon's longitude for the noon of each day from the Ephemeris; if the moon's place be in the same sign for each of the days subtract her longitude on the former day from her longitude on the latter day, and the remainder is her progress, for the past 24 hours.

If the moon pass from one sign into another during the given interval, then, add together the portions of each sign through which she has passed

in the given time, and the sum will be the space she has passed through from noon to noon.

Examples.

Let it be required to find the portion of the ecliptic through which the moon will pass on the 8th of July, 1844.

Her longitude on the 8th of July at noon is, by the Ephemeris shown to be 27° 58′ in Aries
For the 7th at noon, it is 15 55 in Aries

The space passed 12 03

Again, Required the moon's progress in her orbit, from the 14th of September at noon to the noon of the following day?

Her longitude on the 14th of Sept.
at noon is 17° 29′ in Libra
On the 15th it is 1 52 in Scorpio

If from the whole sign Libra	30°	00′
We take	17	29
She has passed of Libra	12	31
To which add of Scorpio	1	52
Her progress from noon to noon	14	23

Prob. 54.

To find the moon's longitude for any particular hour of a given day.

Take, from the Ephemeris, the moon's longitude for noon of the given day; find by the foregoing problem her rate of motion during the preceding 24 hours; and by this estimate the proportionate progress she would make up to the given hour; add

this quantity to her longitude at noon of the given day, if the hour be in the afternoon; but subtract it if the time be in the forenoon; the sum or difference, as may be, will shew her longitude at the given time.

Examples.

Required the moon's longitude at 7 o'clock in the morning, and also at 5 o'clock in the evening on the 15th of September, 1844?

Her rate of motion between the noon of the 14th and that of the 15th of September as shown above is 14° 23′.

$$\begin{array}{l} \quad\;\;\text{hours}\;\;\text{hours} \\ \text{As } 24 : 5 :: 14^{\circ}\ 23' : 2^{\circ}\ 59'\ 4' \end{array}$$

To her longitude at noon on the 15th of September 1° 52′ in Scorpio,

Add 2 59 4 her progress since noon.

The sum is 4 51 4 in Scorpio, her place at 5 o'clock in the afternoon.

To find her position at 7 o'clock in the forenoon, which is 5 hours before noon. As we cannot subtract 2° 59′ 4″ from 1° 52′, to this latter quantity we add the whole sign of Libra, 30°, and from the sum, 31° 52′ subtracting 2° 59′ 4″, the remainder is 28° 52′ 56″ in Libra for the moon's longitude at 7 o'clock in the forenoon.

To find the place of a planet—Take its right ascension and declination for the given day from the Ephemeris, and proceed to find its position as you would that of a fixed star, (prob. 3.)

Exercises.

1. Required the moon's place in her orbit on the 10th of June, 1844, at 4 o'clock in the morning, and also her place at 8 o'clock in the evening?

2. Find on the globe, the position of each of the following planets on the 7th of August, 1844, their right ascensions and declinations being as follows :—

	Right ascension in time.*			Declination.		
Saturn	20h.	22m.	19s.	20°	2'	S.
Jupiter	0	15	40	0	04	N.
Mars	8	7	36	17	43	N.

Prob. 55.

Given the latitude and longitude of the moon or of a planet, to find its place.

Proceed exactly in the same manner as directed in problem 6.

Exercises.

1. On the 9th of October, 1844, the moon's longitude will be 13° 22′ in Virgo, and her latitude 5° 5′ south—find her position in the zodiac.

2. On the 1st of May, 1844, the longitude of Uranus is 4° 23′ in Aries, and its latitude 0° 42′—Find its place.

3. On the 5th of December, 1844, the moon's longitude is 13° 39′ in Libra, and her latitude 4° 8′ south. Find her position in the zodiac.

Prob. 56.

To find the moon's right ascension and declination for any given time.

Find the moon's place by the foregoing problem, and mark it on the globe; bring the place so marked to the meridian; the degree of the equinoctial cut by the meridian will be the right ascension, and the

* The hour distances are generally numbered on the equinoctial: if they be not, however, these right ascensions may be reduced to degrees of longitude, and counted on that circle.

degree of the meridian over the moon's place, or that arc of the meridian between the equinoctial and the moon's place, will show the declination.

Exercises.

1. Required the right ascension and declination of the moon on the 21st of October, at half-past 8 o'clock in the afternoon, her longitude at noon being 3° 46' in Pisces, and her latitude 5° 11' north?

Ans. Right ascension 338°
Declination about 4° south.

2. Required the moon's right ascension and declination at noon on the 3rd of December, her longitude being then 16° 28' in Virgo, and her latitude 5° 11' south?

3. On the 10th of August, 1844, the moon's longitude will be 5° 34' in Cancer, and her latitude 2° 3' S.; what will then be her right ascension and declination?

4. On the 12th of January, 1844, the moon's longitude was 2° 14' in Libra, and her latitude 5° 9' S.; find her right ascension and declination.

PROB. 57.

To find the nodes of the moon, and the position of her orbit with respect to the ecliptic at any given time.

For the nodes.—The place of the ascending node may be found by the ephemeris, and the other node is the very opposite point of the ecliptic.

For the orbit.—Having determined the points of the nodes and marked them, tie a thread round the globe, making it coincide with the ecliptic; then, keeping it fixed at the nodes, elevate about 5¼ degrees that point of the line which is 90° eastward

of the ascending node, and depress the opposite point 5¼ degrees; the line being properly adjusted to the plane passing through those four points, will represent the orbit of the moon for the given time.

Exercises.

1. The place of the moon's ascending node on the 13th of April, 1844, is 16° 47′ of Sagittarius, find her descending node, and show the position of her orbit for that day.

Ans. The following are four points in her orbit, viz. 16° 47′ of ♐, the ascending node; the 347th degree of the equinoctial; 16° 47′ of ♊, the descending node; and the 167th degree of the equinoctial.

2. The ascending node for the 19th of August is in 10° of Sagittarius; required the position of the moon's orbit for that time.

Prob. 58.

To find the moon's western and eastern amplitude, and the time of her southing at any place on a given day.

Find the moon's place for the given time, and mark it; rectify the globe for the given latitude and also for the sun's place; then turn the globe westward till the moon's place comes to the western side of the horizon, and the degree of the horizon directly opposite to it is its western amplitude; continue the motion of the globe to the westward till the moon's place comes to the eastern side of the horizon, and there note her eastern amplitude, turn the globe still westward till the moon's place comes to the meridian, and the hour at the meridian on

the hour circle will show the time that the moon souths, or comes to the meridian after the sun.

Exercises.

1. Required the moon's amplitudes, and the time of her southing at London on the 17th of September, 1844? her longitude on that day at noon being 0° 34′ in Sagittarius, and her latitude 0° 38′ south.

Ans. Western amp. 36° from west towards S.
Eastern amp. 34 from east to south.
Time of southing 17min. after 4, afternoon.

4. What are the moon's amplitudes, and at what time does she come to the south, at London, on the 5th of December, 1844, her longitude for that day being 13° 39′ in Libra, and her latitude 4° 8′ south?

Remark.

When the moon's place is brought to the horizon to find the amplitudes, the time of her rising and setting may be observed on the hour circle—the rising, when her place is at the eastern side, and the setting, when at the western side. The indications, however, will not be always correct.

PROB. 59.

The latitude, day of the month, and hour of the day given, to find the moon's azimuth and altitude when she is above the horizon.

Find the moon's place in her orbit for the given hour, by problems 54 and 55, and mark it on the globe; take this mark as a fixed star, and proceed as taught in problem 16.

Exercises.

1. Required the moon's azimuth and altitude when it is 3 o'clock in the afternoon in London on the 7th of August, the moon's longitude for the noon of that day being 29° 44′ in Taurus, and for the noon of the preceding day, 17° 56′ in Taurus, and her latitude on the 7th, 1° 5′ north?

Ans. By the 54th prob. the moon's longitude at 3 oclock on the 7th of August will be found 1° 12′ 30″ in Gemini; from which, with the given latitude her place is easily determined; then, proceeding according to the problem, her azimuth is found to be 40° from the west towards the south; her altitude, however, may not be taken, as she is below the horizon about 2 or 3 degrees at 3 o'clock.

2. On the 22nd of June, 1844, the moon's longitude at noon being 16° 39′ in Virgo, and on the 23rd at noon 0° 13′ in Libra, required her altitude and azimuth at London on the 23rd, at 8 o'clock in the afternoon, her latitude 5 degrees south?

Prob. 60.

To find what stars lie in or near the moon's course on any given day.

Find the moon's place in her orbit at noon of the day preceding and of that following the given day; mark her position at those two periods; then over the marks stretch the quadrant of altitude; the stars lying in that line are those required.

Or,

By the 57th problem find the position of the moon's orbit for the given day, and this will afford

a more extended view of the stars that are likely to be occulted by the moon on that day.

Exercises.

1. What stars lie in or near the moon's path on the 13th of March, 1844?

Ans. The moon's ascending node for that day is in 18° 26′ of Sagittarius, and her descending node in 18° 26′ of Gemini, and by proceeding according to the 57th problem, it will be seen that her course for that time passes through the following points; viz. π in Sagittarius, the head of Capricornus; the arm and body of Aquarius; the middle of the western, and touching the tail of the eastern of the Fishes; the three stars in the tail of Aires; 3° south of the Pleiades, and 1° north of the Hyades; ζ at the point of the Bull's horn; across the legs of Gemini; the three stars in the claws of Cancer; the paws of Leo; 1½° S. of the bright star Spica Virginis; and the middle of Scorpio.

2. What stars will lie in the moon's course on the 7th of December, 1844, at which time her ascending node will be 4° 11′ in Sagittarius?

Prob. 61.

To find all those places on the earth to which the moon will be vertical or nearly so on any given day.

Find the moon's declination, mark that degree on the meridian of the terrestrial globe, turn the globe on its axis, and all places passing under the degree of declination have the moon vertical or *nearly** so, on that day.

* *Nearly*—Because when the moon is in those signs which are situated about the equinoctial points, she changes her

Exercises.

1. Required the parts of the earth over which the moon passes vertically on the 14th of September, her longitude being 17° 29′ in Libra, and her latitude 4° 33′ south?

2. Over what parts of the earth will the moon pass vertically on the 8th of November, her longitude on that day being 19° 48′ in Libra, and lat. 3° 44′ south?

3. Which are those places whose latitude will equal the moon's declination on the 24th of December, 1844, her longitude at noon on that day being 29° 29′ in Gemini, and her latitude 2° 12′ S.?

PROB. 62.

Given the latitude of the place and the day of the month, to find what planets will be above the horizon after the sun has set.

Rectify for the latitude; bring the sun's place for the given day ten or twelve degrees below the western side of the horizon. Then, as the right ascension of the planets is given in time in the ephemeris, observe those whose right ascension corresponds to the hours of the equinoctial then above the horizon, for they are the planets which may be seen during that night.

Exercises.

1. What planets may be viewed during the night

declination very rapidly, differing four or five degrees in the course of a diurnal revolution; so that she will not be long vertical on the same latitude.

of the 1st of November, 1844, at London? the following being the right ascensions :—

Saturn	♄	20h.	12m.	10s.
Jupiter	♃	23	42	30
Mars	♂	12	33	00
Venus	♀	11	44	30
Mercury	☿	13	51	10

Ans. Saturn and Jupiter.

2. What planets may be seen after sun-set at London on the 20th of February, 1844? the right ascensions of the planets on that day being as follows :—

Saturn	20h.	16m.	59s.
Jupiter	22	40	15
Mars	1	16	41
Venus	0	16	48
Mercury	20	26	37

Moon's longitude at noon 26° 2′ in ♓

Prob. 63.

The latitude of the place, and day of the month being given, to find how long Venus or Jupiter, when an evening star, sets after the sun; or how long before the sun either of them, when a morning star, will rise.

Rectify the globe for the latitude of the given place; find the right ascension and declination of the given planet for the day, and mark its position; bring the sun's place to the meridian, then, if the place of the planet be to the right of the meridian, it is an evening star; if to the left, a morning star.

If an evening star—Bring the sun's place to the western edge of the horizon, and set 12 to the meridian; turn the globe westward, till the planet's

place comes to the western edge of the horizon, and the hours which have passed the meridian from 12, will show how long after the sun the planet sets.

If a morning star—Bring the place of the planet to the eastern side of the horizon, and set the hour circle to 12 as before; turn the globe westward till the sun's place comes to the eastern side of the horizon; and the hours which pass the meridian will show how long before the sun the planet rises.

Exercises.

1. On the 7th of February, 1844, the right ascension of Jupiter is 22h. 28m. 31s. and his declination 10° 36′ south; whether is he a morning or an evening star? If a morning star, how long before the sun does he rise at London; if an evening star, how long is he above the horizon after the sun has set?

Ans. Jupiter is at this time an evening star; and does not set till one hour and thirty-four minutes after the sun.

2. On the 7th of September, 1844, the right ascension of Venus is 8h. 12m. and her declination 15° 36′ north; whether is she then a morning or an evening star? If the former, how long before the sun does she rise at London, if the latter, how long is she above the horizon after sun-set?

Ans. Venus is a morning star, and rises 3h. 44m. before the sun.

PROB. 64.

On the precession of the equinoxes.

Observations.

The axis of the earth does not always keep paral-

lel to itself, but has a proper motion of its own, which, though not sensible in the space of two or three years, will in a century or two make a great difference in its position; the axis does by this motion describe the surface of a cone, whose vertex is in the centre of the earth, and its base a lesser circle, which the pole of the earth describes round the pole of the ecliptic, from east to west; and as these poles always preserve the same distance of 23½ degrees from each other, the diameter of this circle will be 47 degrees; and as the solstitial colure always passes through the poles of the earth, when the pole changes its situation, the colure will do so likewise; and when the pole has proceeded one degree to the west, (which will happen after 72 years,) the colure will be one degree more westward on the ecliptic; and as all the points in the ecliptic always keep the same distance from each other, they will all partake of this motion. This is called the motion in antecedentia; and that of the earth and planets round the sun, in consequentia. By this precession of the equinoxes the longitude of the stars is increased; for their longitude being computed from the first point of Aries, eastward, as this point falls back to the west, (the stars remaining immoveable,) their distance from it, that is, their longitude must increase.*

To illustrate the above by the globe.

Elevate the north pole 90 degrees above the horizon, by which means the equinoctial and horizon will coincide; bring the pole of the ecliptic to the brass meridian, and make a mark on the meridian

* Ferguson's Astronomical Lectures.

exactly above it; let this mark be considered as the pole of the world, let the equinoctial represent the ecliptic, and let the ecliptic be considered to be the equinoctial. From the supposed pole of the world (the mark made on the meridian) count 38½ degrees, upwards; the place where the reckoning ends will stand over the latitude of London: mark it. Now turn the globe slowly on its axis, from east to west; the equinoctial points will move the same way, and the pole of the world (that is in this case the pole of the ecliptic,) will be observed to describe a circle round the pole of the ecliptic, (that of the world).

The revolving pole takes 72 years to pass through one degree, the motion is, therefore, exceedingly slow, requiring a period of 25,920 years to complete its revolution. This period has been called the Grand Platonic Year. By referring to the mark which was made over the latitude of London, and turning the globe half round, it will be seen that when half the Platonic Year has elapsed, the north pole will be in that point of the heavens which is now 8½ degrees south of the zenith of London.

THE UNIVERSE.

"When I consider Thy heavens, the works of Thy fingers, the moon and the stars which Thou hast ordained; what is man that Thou art mindful of him."—*Psalm* viii. 3, 4.

What David felt, who must not feel,
That views the worlds which round us wheel
Their course untiring? What a sight!
How great the Power that guides their flight!

Amazing orbs ! whose distance, size,
And motions, all alike surprise,—
How is their ponderous weight sustained,
Their flight directed—force restrained ?

They move in graceful dance along,
They chant Creation's glorious song ;
The praise of Him who reigns on high
They sing in concert as they fly.

Amid that bright revolving band,
The SUN obtains a central stand ;
Of light and heat appointed source,
Round him the Planets take their course.

First, bordering on his flaming rays,
The fleet-winged *Mercury* round him plays ;
Oft, robed in beams, this child of light
Evades the search of earthly sight.

Venus, at *seventy million miles*,
His fervid look with silvery smiles
Reflects. Then on our *Earth and Moon*
At *ninety-five* his rays are thrown.

At *ten times fifteen millions*, *Mars*,
With fiery blush among the stars,
Obedient to the solar powers,
Completes his year in two of ours.

Vesta and *Juno* moving near
Ceres and *Pallas*, next appear ;
Four years these sun-lit sisters take,
Their circum-solar course to make.

Next, *Jupiter ;* one year of his
Is twelve of ours ; his distance is
Five hundred million miles, or more ;
His *moons*, called satellites, are *four*.

Nine hundred million miles away,
On broad-ringed *Saturn* sun-beams play ;
Seven moons attend him as he veers,
His tedious round of thirty years.

But *doubly distant* is the path,
The gloomy, *six-moon'd Herschel* hath;
In *four score years and four* is run,
His spacious circuit round the sun.

Next—tourist of all-varying skies,
Who astronomic skill defies
To trace his curve, compute his time,
Assign his distance, or his clime—

The eccentric *Comet* soars afar,
Outspeeds the morning, evening star;
Remote, he freezes: near, he burns;
Braves all vicissitudes by turns.

Thus far we know; but, vision fails,
Nor telescopic aid avails,
To scan the numerous worlds that roll
Round many a glowing distant pole.

No limits circumscribe their race,
They compass every point of space;
Through regions even by thought untrod,
They speak the praise—the power of God.

Small is the portion we can know;
Who through all space a glance could throw;
Would deem th' extent surveyed by man,
The solar system—but a span.

Creation's problem could we solve,
System round system may revolve;
And countless systems as a whole,
Round Great Jehovah's throne—their pole.

And there, in glad and thankful strains
To Him who made them and sustains,
Pour songs of praise, while every song,
Echoes from orb to orb along.

Awake O Earth! thou much caress'd,
Lift up thy voice among the rest;
They, for Creation, grateful prove,
Be thy sweet theme Redeeming Love.

THE END.

K

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A portion of the ocean, in which numerous islands are thickly interspersed, is called an archipelago.

Besides these oceans there are many smaller portions of water not connected with them, being entirely surrounded by land; these are called lakes.

When a portion of land is nearly, though not entirely,

SPECIMEN PAGE OF THE

HAND BOOK OF ENGLISH GRAMMAR.

21. *One*, *other*, and *another* are declined like nouns; *another* has no plural. *None* is used in both numbers, and is never joined in both numbers.

VERB.

1. A verb is a word which asserts being, doing, or suffering something done; as, *He is a man; he walked through the garden; he repeated his lesson; he has been beaten severely.*

2. It is called *verb*, that is, *the word*, because it is the principal word in a sentence; as no sentence is complete without a verb.

3. When a verb signifies *to do* it is called *active*; when it asserts the suffering of an action, it is called *passive*. A verb which affirms neither action nor suffering but merely being in a certain state, is *neuter*.

4. The passive voice is in reality a phrase, and not a single part of speech. Thus, in the sentence, *the boy is beaten by the man*, the phrase *is beaten* indicates the state of suffering or endurance in which *the boy* exists.

5. A verb active requires to be followed by a noun in order to complete the sense; when it is said, *the man beats*, the sentence is incomplete unless a word indicating what he beats be added.

6. In verbs active the agent, or that which acts, goes before the verb; it is called the *subject* of the verb, and is generally a noun in the nominative case.

7 The person or thing acted upon follows the verb in the objective case, and is called the *object* of the verb.

8. The neuter verb signifies either being; as, *I am, he exists;* or in a state or condition of being; as, *I stand, he sleeps, we walk, they think.* Verbs neuter are distinguished from verbs active by making sense of themselves without any addition.

9. Many verbs have both an active and a neuter signification; as, *Camphor dissolves in oil; oil dissolves camphor.* In the first clause of this sentence the verb *dissolves* is neuter, in the second active.

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ABBREVIATION—L. *ad*, to, *brevis*, short—A contraction of a word. 107.

ABDUCTION—L. *ab*, from *duco*, I lead—A leading away. 53.

ABILITY—L. *habilis*, able—Capable of action. 36.

ABLALIVE—L. *ablatus*, taken away—The sixth case of a Latin noun. 22.

ABRUPTLY—L. *ab*, from *rumpo*, I break—Suddenly. 108.

ABSOLUTE—L. *absolutus*, cleared—Complete in itself. 83.

ABSTERGENT—L. *abs*, from, *tergo*, I wipe—Cleansing. 53.

ABSURD—L. *ab*, from *surdus*, deaf—Ridiculous. 88.

ABUNDANCE—L. *abundo*, I abound—Great plenty. 58.

ABUSE—L. *abutor*, I abuse—To use improperly. 83.

ACCEDE—L. *ad*, to *cedo*, I yield—To yield to. 53.

ACCENT—L *ad*, to, *cantus*, a song—Stress of the voice; to pronounce forcibly. 9.

ACCIDENT—L. *accido*, I happen—A property not essential to its subject. 33.

ACCOMPANIMENT—F. *accompagner*, to keep company with—What goes along with something else. 52.

ACCOMPLICE—F. *accomplir*, to finish—A companion in crime. 106.

ACCURACY—L. *ad*, to, *cura*, care—Exactness. 77.

ACCUSATIVE—L. *accuso*—I accuse—The fourth case of a Latin noun. 22.

ACTIVE—L. *ago*, I do—Signifying doing. 32.

ACTOR—L. *ago*, I do—The doer of a thing. 16.

ACUTE—L. *actus*, sharp—A kind of accent. 109.

ADAMANTINE—L. *adamas*, diamond—Extremely hard. 58.

ADAPT—L. *ad*,to, *aptus*, fit—To fit to, 53.

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il	*it*
est	*is*
huit	*eight*
heures.	*o'clock.*
2. Il	**It* or *you*
faut	*must*
vous	**you*
lever.	*get up.*
3. Est	*Is*
il	*it*
si	*so*
tard?	*late?*
4. Le	[2]*The*
déjeûner	[3]*breakfast*
est	[1]*is*
il	**it*
prêt?	[4]*ready?*
5. Votre	*Your*
soeur	*sister*
est	*is*
déjà	*already*
descendue.	*gone down.*
6. Dépêchez —vous	*Make haste*
de	*to*
vous	[2]*yourself*
habiller.	[1]*dress.*
7. Voilà	*Here are*
vos	*your*
bas,	*stockings,*
votre	*your*
robe.	*frock.*
8. Lavez	*Wash*
vous *you* les *the*	*your*
mains.	*hands.*
9. Voici	*Here is*
le	*the*
savon,	*soap,*
et	*and*
l'	*the*
essuie-mains.	*towel.*
10. Avez	*Have*
vous	*you*
de l'	*some*
eau	*water*
dans	*in*
la	*the*
cuvette?	*basin?*
11. Venez	*Come*
ici,	*here*
Je	*I*
vais	**go* [1]*will*
vous	**you*
brosser	[2]*brush*
les	**the* [3]*your*
cheveux.	*hair.*

12. Où	*Where*
sont	*are*
vos	*your*
petits	**small, side*
peignes.	*combs.*
13. Ils	*They*
sont	*are*
dans	*in*
le	*the*
tiroir.	*drawer.*
14. Apportez	*Bring*
les,	*them,*
prenez,	*take*
aussi	*also*
vos	*your*
mitaines.	*mittens.*
15. Attachez	*Tie*
moi	**me*
mon	*my*
tablier.	*apron.*
16. Voyons	*Let us see*
si	*if*
vous	*you*
êtes	*are*
bien	*very*
propre.	*clean.*
17. Oui,	*Yes,*
vous	*you*
pouvez	*may*
descendre.	*go down.*

Le Lever.

1. Mad*e*moiselle il est | huit *h*eures.
2. Il faut vous l*e*ver.
3. Est-il si tard?
4. Le déjeûner est-il prêt?
5. Vot*r*e soeur est déjà descendue.
6. Dépêchez-vous d*e* vous *h*abiller.
7. Voilà vōs bās, vŏt*r*e rŏbe.
8. Lăvez-vous les mains.
9. Voici l*e* savon, | et l'essuie-mains.